LIBRARY
University of California Library Campus

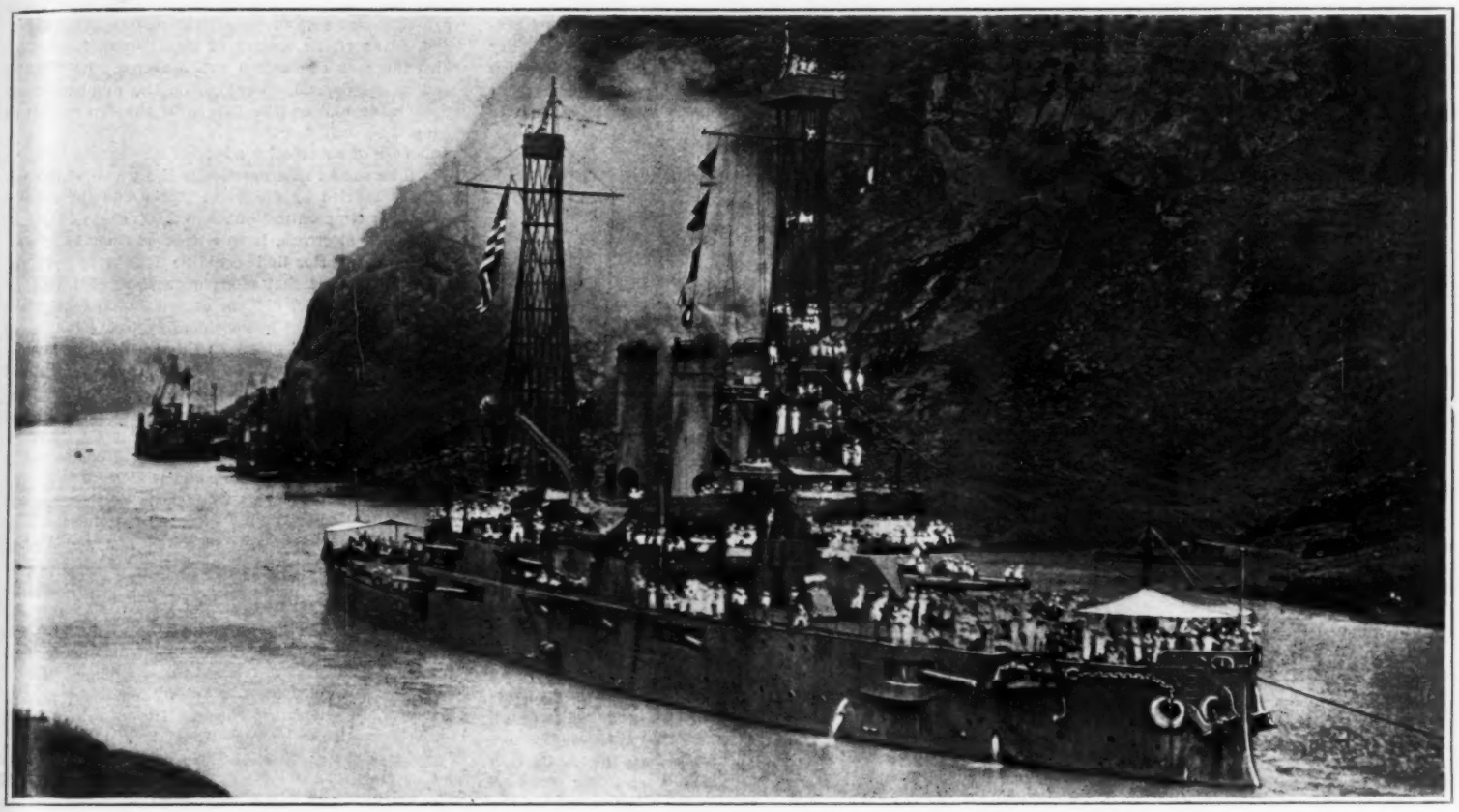
SCIENTIFIC AMERICAN SUPPLEMENT

Copyright 1915 by Munn & Co., Inc.

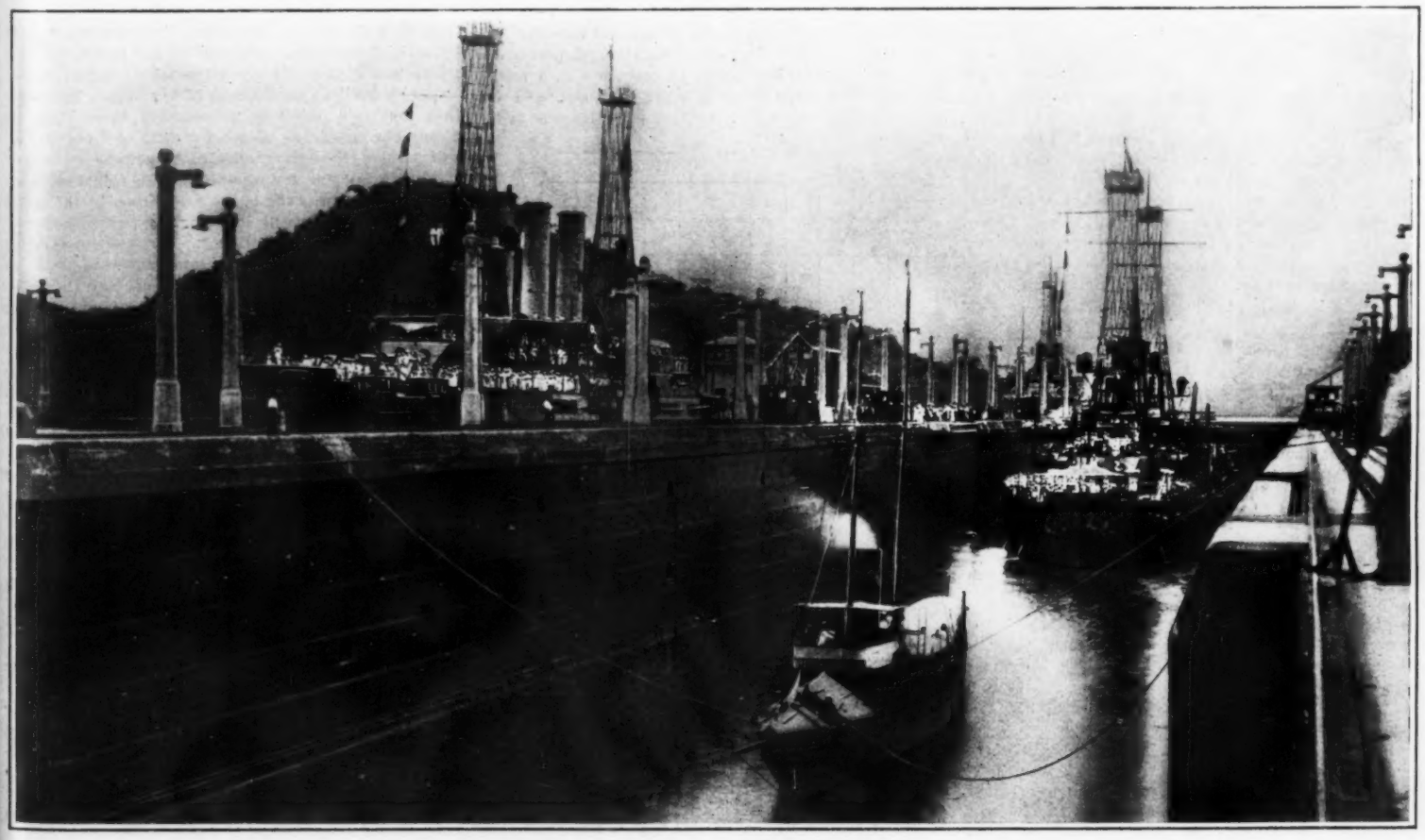
VOLUME LXXX
NUMBER 2068

NEW YORK, AUGUST 21, 1915

10 CENTS A COPY
$5.00 A YEAR



The United States ship "Ohio" in the Panama Canal. The Cacarachua slide in the background.



The "Ohio," "Missouri" and "Wisconsin" in the Pedro Miguel Locks.

THE UNITED STATES FLEET IN THE PANAMA CANAL.—[See page 117.]

The Conductivity of Metals*

A New Theory of the Passage of Electricity Through Metals

By Sir J. J. Thomson

In opening his lecture, Sir J. J. Thomson said that one of the most striking properties possessed by metals was their power of conducting large currents of electricity, and it was to this property that much of their industrial importance was due. Without this conductivity we should have to revolutionize methods of lighting, communication, and transport. It was not, however, to the industrial aspect of conductivity that he wished on this occasion to draw attention, but he proposed rather to consider certain suggestions that had been advanced as to the manner in which currents of electricity were conducted, and to consider how the results would affect our views as to the structure of metals. It was, he said, somewhat remarkable that although the currents passing through metals day by day and week by week were enormously greater than currents through gases and liquids, yet our knowledge of the manner in which electricity got through gases and liquids was very much more definite, and rested on a much surer foundation. It was somewhat interesting to note that the views now held as to the way in which metals conducted electricity were derived from the study of gases, and not of liquids, although in their physical properties liquids were the more closely connected with metals. In spite of this, the fact remained that it was in the study of conduction in gases that the views now held as to metallic conductivity originated.

A subject of such vast importance was naturally a matter of speculation from early times. All the theories then advanced, however, met with one insuperable difficulty. In all it was assumed that the electricity was carried by matter. Hence, if electricity passed through a metal, the atoms of the latter should also move, and thus on these old theories the transport of electricity ought to have been accompanied by, at any rate, some transport of atoms. Experiments made to get evidence of this were of two kinds. In the first place very large currents were passed, for a very long time, through alloys. The alloy was then analyzed, samples being taken both from the end at which the current went in and from that at which it came out. If the transport had been effected by atoms, the passage of the current should have resulted in a difference in the constitution of the two ends. Actually, however, not the slightest evidence of this was perceptible, the current having left the alloy entirely unaffected. In another experiment plates of lead and gold were pressed together, and a large current passed from the gold to the lead for a very long time. The metals were then examined to see if there had been any undue penetration of the one metal by the other. Not a trace of this was to be found, although the current across the junction had been continued long enough to deposit electrolytically more than the whole weight of the metals used.

In short, no progress was made toward a satisfactory theory of conduction in metals until it was discovered that other bodies besides atoms and molecules could act as carriers of electricity. These bodies, known as corpuscles or electrons, were extremely small in comparison with atoms. The electricity they carried was always negative, and the bodies themselves were the same from whatever substance they might be derived. On the discovery of these electrons metallic conductivity took on a new aspect. It was seen at once that if these bodies acted as carriers, the transport of electricity would not necessarily imply a simultaneous transport of the atoms of the metal, and hence the theory of conductivity entered on a much more promising phase.

Very soon a theory was started that the electricity was carried through the metal by a large quantity of electrons contained in the metal, which, under the influence of the applied electromotive force, drifted through the metal and thus produced a current. The hypothesis involved the presence in the metal of large quantities of electrons. Moreover, if the metal with its charge of electrons were neutral as a whole, the atoms must be positively electrified, the positive electrification being proportional to the number of the electrons. For example, if there were seven or eight times as many electrons as atoms, each atom would have to carry seven or eight positive charges. It was known, however, that the atoms could not carry these very large charges. It was true that there was a great number of electrons at the center of the atom, but these were too firmly fixed to be liberated by the forces ordinarily involved in metallic conduction.

* From *Engineering*.

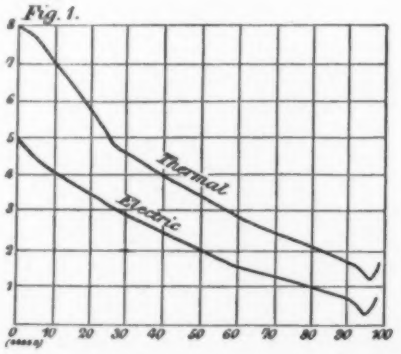
The idea that the metal was filled with electrons appeared at first very promising, explaining many known effects. Among these might be cited the close connection between the conductivity of a metal for electricity and its conductivity for heat. It was generally known that a good conductor of the one was also a good conductor of the other, but few realized that at ordinary temperatures the one was very accurately proportional to the other. This proportionality was, the speaker said, very well shown by the annexed table, due to Jäger and Dieselhorst.

Material.	Thermal Conductivity / Electrical Conductivity At 18 deg. Cent.	Temperature Coefficient of this Ratio per cent.
Copper, commercial ..	6.76 × 10^{10}	—
Copper (1), pure	6.68 × 10^{10}	0.39
Copper (2), pure	6.71 × 10^{10}	0.39
Silver, pure	6.86 × 10^{10}	0.37
Gold (1), pure	7.27 × 10^{10}	0.36
Gold (2), pure	7.09 × 10^{10}	0.37
Nickel	6.99 × 10^{10}	0.39
Zinc (1)	7.06 × 10^{10}	0.38
Zinc (2), pure	6.72 × 10^{10}	0.39
Cadmium, pure	7.06 × 10^{10}	0.37
Lead, pure	7.15 × 10^{10}	0.40
Tin, pure	7.36 × 10^{10}	0.34
Aluminium	6.86 × 10^{10}	0.43
Platinum (1)	7.76 × 10^{10}	—
Platinum (2), pure ..	7.53 × 10^{10}	0.46
Palladium	7.54 × 10^{10}	0.46
Iron (1)	8.02 × 10^{10}	0.43
Iron (2)	8.03 × 10^{10}	0.44
Steel	8.03 × 10^{10}	0.35
Bismuth	9.64 × 10^{10}	0.15
Constantan (60 Cu 40 Ni)	11.06 × 10^{10}	0.23
Manganin (84 Cu 4 Ni 12 Mn)	9.14 × 10^{10}	0.27

As would be seen from the figures given, the ratio was extremely constant. Perhaps the connection between the two conductivities was even more strikingly shown by the curves in Fig. 1, in which the lower one showed the electrical conductivity of the bismuth lead alloys as the proportion of the constituents varied and the upper the corresponding thermal conductivity. As would be seen, the correspondence between the two was remarkably close, even the kink in the one being reproduced in the other. This connection between the two conductivities was readily explained on the assumption that a mass of metal was charged with free electrons which acted as if they constituted a gas occupying the whole volume and in thermal equilibrium with the metal, so that the heat and the electricity were conveyed by the same mechanism.

Contact differences of potential could also be accounted for on this hypothesis. The metal in which the pressure of the corpuscles was high would part with negative charges when placed in contact with a metal in which the corpuscular pressure was less, and on separating the two a difference of potential was to be expected.

Fig. 1.



The same hypothesis also would account for the transport of electricity by heat. In fact, at first the theory seemed to be very satisfactory all round; in short, a most promising child, in which, indeed, the speaker had taken a special interest, as he believed he was the first to suggest that all currents were carried by electrons. On further growth, however, this infant developed some most undesirable characteristics, turning out a veritable cuckoo; since, when the properties needed for its own accommodation were satisfied, all the other properties of the metal had to go overboard. This became apparent when an actual calculation was made of the number of electrons required to explain the conductivity of such a metal as silver. On the theory it would be seen that the conductivity of a metal would depend upon the number of electrons in unit volume, and also on the speed with which they moved under unit force—that was to say, on the product Nk, where k denoted the mobility and N the number of negative particles. Measurements of the conductivity gave the value of this product, and that of the separate factors could be estimated by other methods, one direct and the other indirect. The first was based on the fact that the speed with which the electrons moved through the metal would depend upon the resistance they experienced when they met with or passed through an atom. These acted, in short, as centers of disturbance, in crossing which the path of electron was deflected. Its effective speed would depend, therefore, on the number of collisions made and on the nature of the forces exerted during these collisions.

One case of electrical conduction was known in which it could be shown that practically the whole of the current was carried by electrons. This was the case in flames at a temperature of about 2,000 deg. Cent. The speed of the electrons, it was true, was not known exactly, but a superior limit could be fixed with certainty. The result showed that along a gradient of 1 volt per centimeter the speed did not exceed 10,000 centimeters per second. It might be considerably less, but it could not be apparently greater. In this case the number of collisions between atoms and electrons was known, and on the supposition that collisions between the electrons and the atoms of metals corresponded to the collisions between electrons and the molecules of a gas, then the speed in the metal would be inversely proportional to the collisions made, and one could pass from the flame to the metal by comparing the density of the atoms in the two conditions. It thus appeared that in silver the speed could not exceed 1.5 centimeters per second along the same pressure gradient as before. If k were defined as the speed under unit force, the corresponding velocity was only $(1/10)^8$ centimeter per second. This was a very slow motion, and since the product Nk was large, there must, on the theory under discussion, be a very large number of electrons in unit volume of silver, amounting, in fact, to ten or twenty times the number of atoms. In order that the metal as a whole should remain neutral, these atoms would have to carry very large charges. Further, if the electrons behaved like gaseous molecules, they must have the same energy as a gas at the same temperature, and thus possess a specific heat. If this specific heat were calculated, however, it came out many times the whole specific heat of the metal, so that the atoms of the latter would have to have a negative specific heat.

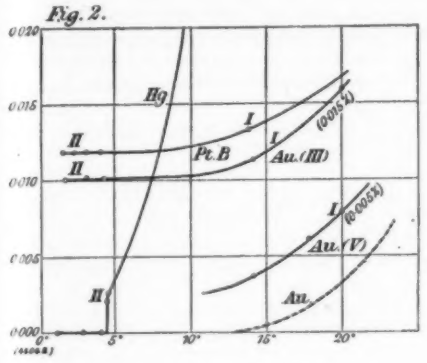
Another estimate of the speed of the electrons could be derived from measurements of the resistance of a metal under very rapidly alternating electric forces. Using light with a wave-length of 4 μ, Rubens had found that the resistance was 20 per cent more than for steady currents. The value of k deduced from this result was of the same order of magnitude as before. Hence, to account for conductivity on this hypothesis demanded the presence of more electrons in the metal than was consistent with its other physical properties.

To his own mind this argument afforded a convincing proof that metals did not contain enough electrons to explain their conductivity. He did not say that they did not contain some electrons; in fact, a Coolidge tube had been giving them out for a year, and he did not deny that they played some part in metallic conduction, but he was convinced that they had little to do with the conductivity of such metals as silver, copper, and other good conductors.

Another argument against the theory was afforded by the remarkable experiments of Kamerlingh Onnes on the connection between the resistance of a metal and its absolute temperature. In this connection he would consider solely the case of pure metals, since the theory of conduction of mixtures was entirely different. Roughly speaking, the resistance of a pure metal was proportional to its absolute temperature, and any theory of metallic conduction should bring out this result at once. As a matter of fact, it was difficult to reconcile the free electron theory with the relation between temperature and resistance. It would be seen that the product Nk measured the conductivity, and at very low temperatures this conductivity is large. Hence, either N or k must be large. A large increase in N was highly improbable, since, after all, the presence of these electrons must be due to some kind of dissociation, which in all known cases was greater at high than at low temperatures, increasing, in fact, very rapidly as the temperature rose. Hence, it was to be expected that N would diminish rapidly as the temperature fell. An enormous increase would, therefore, be necessary in k, the other factor of the product, but this was very improbable. In short, he had never seen any adequate

explanation on the free electron theory or even the old rough relationship between temperature and resistance, and the further experiments of Kammerlingh Onnes put the hypothesis quite out of court. Working at the temperature of liquid helium, Kammerlingh Onnes had got some most surprising results, having at 4 degrees absolute got metals in a state in which the resistance was not one-seventieth of that at 0 deg. Cent. as by the old rough relationship, or even one-thousandth of this resistance, but had found it to be reduced to the astounding figure of less than 1/10,000 millionth of the resistance at 0 deg. Cent. To get this result, the metal had to be very pure; otherwise the resistance did not diminish in this way, but followed a law such as represented by the curves for gold in Fig. 2. In this figure it would be seen that the resistance of mercury fell to a limit far too small to measure, but it was certainly less than the figure given above.

Fig. 2.



The result stated was sufficiently striking, but Kammerlingh Onnes had gone further. Having obtained a ring of lead in this super-conducting condition at 4 deg. A, he started a current in it, which, without further expenditure of energy, was found, at the end of four hours, to be still within 1 per cent of its initial value. From this it would appear that in four days it would have fallen to half value. In a perfect conductor, of course, a current once started would go on forever, but he thought it would be admitted that, in this case, four days represented a very fair first approximation to eternity.

It was clear from these results that metals could be got into a state in which their electrical properties differed entirely from what they were at ordinary temperatures. In fact, these properties appeared to depend upon a certain critical temperature, on passing through which the electrical properties underwent changes quite as marked as their elastic properties did when melted.

The free-electron theory of conduction did not seem to afford any suggestion of an explanation of this effect, and he wished, therefore, to bring forward another theory, of which this critical change of properties would be one of the most obvious consequences, and which led at once to the law that at ordinary temperatures the conductivity was nearly proportional to the absolute temperature.

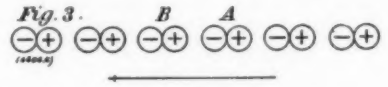
In some respects the theory was an old one, having in its essential features been brought forward by the speaker thirty years ago. It was then, however, upset by the fact that the electron was unknown as a carrier of electricity, and the suggestion had to be dropped.

The easiest way to present it was, perhaps, to call attention to certain analogies it had with the molecular theory of magnetization. On this view a bar of iron consisted of a great number of little magnets, which in the ordinary state of the bar lay all higgledy-piggledy, and had no resultant effect. When a magnetizing force was introduced these little magnets were pulled more or less into line, and some sort of order being thus introduced, the iron became a magnet. An essential point was, Why did they not all come into this line? The answer was, They tried to do so, but in consequence of their thermal agitations knocked each other out as fast as the magnetizing force pulled them in. Hence, the net result was a differential one; only a fraction came into line, this fraction being smaller the higher the temperature. In particular cases this fraction could be calculated, and it was found to diminish rapidly as the temperature rose. Taking this as an analogy, suppose that all bodies were built up of "dipoles" analogous to the elementary magnets of the iron bar. Each bipole consisted of a positive and a negative charge separated by a small distance. Such a collection of bipoles would tend, under the action of an electric force, to point all in the same direction, producing a state analogous to the magnetization of iron. This getting into line constituted Maxwell's displacement current, now better known as dielectric polarization, and in the case of an insulator depended on the specific inductive capacity.

This alignment of the atoms under the influence of electric force might go on in any material, but the peculiarity of metals lay in the fact that their atoms easily parted with electricity. Thus, suppose them to be arranged as in Fig. 3. Each exerted forces on its neighbor, the positive charge tending to pull a negative charge out of the atom next to it. The difference between metals and insulators was that in the insulator this pull was resisted, while in the case of metals the electrons came out, though the electrons which came out need not necessarily be the electrons in the doublet. There was a definite pull on each atom, and a definite number of electrons passed per second.

Suppose the atoms to be arranged in chains, as in Fig. 3, and that n chains pass through unit area. On this theory the quantity of electricity passing through unit area per second would be represented by $n\,e\,p$,

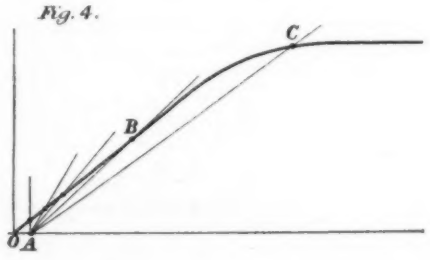
Fig. 3.



where p was the number of electrons passing along each chain, and e the charge carried. In this expression p corresponded to the mobility k of the old theory. In the old theory the number of electrons taking part in the conduction did not depend on the electric force, but the mobility did. On the view now proposed, however, the number of chains per unit of area depended upon the electric force, and p depended only on the nature of the metal. It was, he might add, the variation in n which was responsible for the extraordinary results attained by Kammerlingh Onnes.

From calculations made by Langevin as the result of experiments on gases, a curve could be plotted showing the number of dipoles I alined in one direction. This curve was of the character shown in Fig. 4, but the

Fig. 4.



vertical scale had been enormously compressed. If plotted to the same scale as the abscissæ, it would reach to the moon. The ordinates I were plotted not against the electric force, but against a function of this force defined by the relation:

$$x = \frac{M}{R\theta}(X_0 + kI),$$

where M denoted $d\,c$, the moment of a doublet, R was the gas constant, and θ the absolute temperature. The effective force $X_0 + kI$ is equal to the applied electric force X_0 plus a part of kI due to the action of the dipoles one on the other. This was a very large quantity, and at low temperatures much exceeded the external electric force applied.

Solving for I in terms of x gave

$$I = \frac{R\theta}{Mk}x - \frac{X_0}{k}$$

an equation represented graphically by a straight line which was steeper the higher the temperature. Plotting this on the same diagram as Langevin's curve, the intersection of the two fixed the current which could pass through a metal at that particular temperature and external electric force. The first part of Langevin's curve was a straight line, when the intersection took place on this portion I was proportional to X_0, and Ohm's law held. As the temperature fell, the slope of the line diminished until it became less steep than the straight part of Langevin's curve. So long as the slope was steeper than this limit, the current would cease when X_0, the external force, was made zero, since Langevin's curve would be cut at its origin.

If, however, the slope became less than that of Langevin's curve, the latter would be cut at a distance point, even when X_0, the external force, was made zero. Hence the current, once started, would continue to circulate in the conductor, requiring no external force to maintain it. The condition was then analogous to the fact that magnetism could be retained, as in permanent magnets, after the magnetizing current was broken. Hence, on this view, below a certain critical temperature no electric force would be required to maintain a current, once established, and this was the condition of affairs reached by Kammerlingh Onnes. He had assumed for the sake of definiteness that I was represented by Langevin's curve; this, however, was not essential to the theory, which only required I to be a function, not necessarily Langevin's function, of $MX/R\theta$.

The doublets in the chains exerted strong forces on each other, and hence, when once in line, had a strong tendency to continue so, but at the same time there was a tendency for each chain to be knocked to pieces by the impacts of the molecules. If, however, the intensity of the molecular collisions fell below a certain value, the chain remained unbroken. On this theory, the function of the electric force was to form the chains, and the conduction of the electricity then resulted from the action of the doublets on each other, so that when a chain was formed, the current would continue so long as the thermal agitation was insufficient to break up the chain. All this pointed to a change of state, and the speaker thought it probable that the change from a solid to a liquid was determined by very similar conditions. In a solid, an atom remained in an invariable position, and was, so to speak, chained. These chains were bombarded by the molecular agitation, but up to a certain temperature this was insufficiently intense to break the chain, and the solid state persisted. Above the temperature of fusion, however, the chains no longer held together, and the liquid state was assumed in which there was no fixity in the relations between different atoms. This was perhaps only a rough analogy, but the distinct change in the electric state of metals discovered by Kammerlingh Onnes was certainly largely analogous to the change from the solid to the liquid condition, and from the crystalline to the amorphous.

The forces holding together the chains of dipoles in metals were relatively very feeble, and hence it was necessary to go to the lowest temperatures to obtain coherent chains. The discovery showed very strikingly the importance of liquid helium. At the temperature of liquid hydrogen there was no suspicion of this change of state, and the whole phenomenon was, he thought, a most striking instance of the truth of Browning's line, "The little more, and how much it is."

Extinguishing Fire With Kerosene

WHAT would you think if you got a hurry-up call for kerosene to put out a fire? Probably you would request a repetition of the order, thinking you had not heard aright, and when it was repeated without change you would feel justified in concluding that some one was mentally off balance or attempting a practical joke. But that would be because you never lived in Calexico, Cal., the metropolis of Imperial Valley, and by the same token knew nothing about cotton in the bale.

Exactly such a rush order as this under discussion recently went out from the Cotton Yard at Calexico to the Standard Oil Company station at the same place. Now, the Standard man in charge knew a lot about kerosene, and something about cotton (as every one in the Imperial Valley does), and so he didn't ask for any repetitions or explanations. He saw to it that the order was filled with all possible speed—in this instance even putting forth a little extra effort. Perhaps he happened to recall, "For best results use Pearl Oil." At any rate, Pearl Oil is what he sent, and Pearl Oil it was that extinguished the fire in the Calexico Cotton Yard. Due to a poor market the Calexico Cotton Yard at the time of the fire contained a big part of the season's crop, which had been stacked there in the form of five-hundred-pound bales, so the extinguishing of the fire was a vital matter to many of the valley growers.

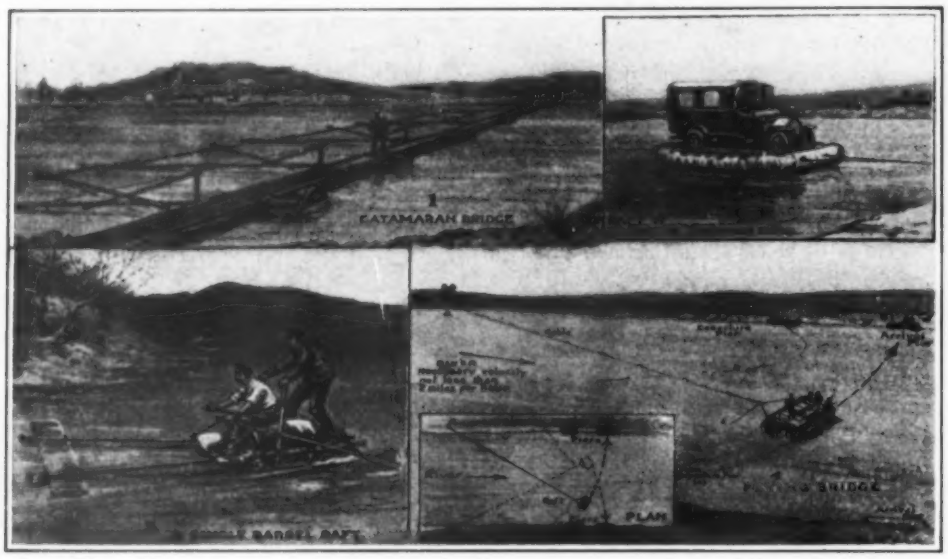
To us, whose chief interest is in how the fire was extinguished, it matters little how it started, though it might be stated that the presumption is that a box-car tourist who had selected the Cotton Yard for a lodging for the night went off into Dreamland without extinguishing his "jimmy" pipe. Now as to how the fire was put out: those who have never been any nearer to the cotton industry than a levee scene in a minstrel show undoubtedly will be interested to know how kerosene could be applied to extinguish fire in cotton bales. It is explained to the *Bulletin* in this way: a cotton bale has been subjected to a very heavy pressure; water will penetrate it but an inch or so, whereas kerosene will go clear to the center; a fire in a cotton bale does not blaze, simply smolders and eats its way into the bale; at the comparatively low temperature at which cotton burns, and where there is no flame, kerosene does not ignite, and that's the explanation. After the fire is extinguished the bands are removed from the bale and the burned portions of the cotton stripped off. It is said that the use of kerosene has practically no detrimental effect on the cotton, and after it has been spread out and aired for a few days all odor of the oil disappears.

The *Bulletin* cautions all who experiment with kerosene as a fire extinguisher to proceed with extreme care.—*Standard Oil Bulletin.*

Pontoon Bridges and Rafts*

How An Army Moves Itself Across Rivers

THE transport of troops on active service over narrow streams which can be crossed by means of single-span bridges, or over rivers in which the depth of water and the nature of the bottom permits the use of intermediate supports, is a comparatively simple matter.



When, however, the above conditions do not exist, it becomes necessary to construct a bridge which relies on the water for its intermediate supports.

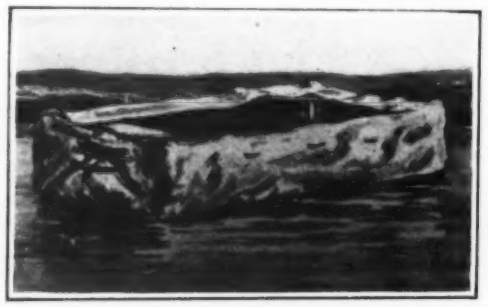
Water-borne bridges may be divided broadly into two classes: (1) The pontoon bridge, in which the whole construction remains in a fixed position, though supported by the water, and the traffic moves over it; (2) The raft, which is a roughly constructed boat, and which is propelled from one bank to the other, the material carried remaining stationary during transit.

A very useful form of pontoon bridge known as the catamaran bridge (Fig. 1 in above picture) may be constructed on the following lines where a supply of casks, spars, and planks is available. Two parallel lines of spars long enough to span the river are lashed together about one foot apart. Beneath these, at intervals of about ten feet, large casks are secured, the casks being allowed to float upon the surface of the water. Between the parallel lines of spars the plank roadway is laid, resting on the casks. A number of long spars are secured to the parallel track at right angles to its direction, their outer ends being connected by another timber which acts as an outrigger to prevent the roadway from capsizing. This bridge can only be used by troops in single file.

When it is desired to transport mounted troops, wagons, guns, etc., a much wider roadway and more substantial form of construction are necessary, which can be provided, when sufficient boats are available, in the form of a common pontoon bridge, in which the boats are anchored side by side to support the roadway laid across them. Where boats or pontoons are not available, their places are sometimes taken by floats consisting of a wooden framework covered with tarpaulins or wagon cloths (Fig. 5).

A moving bridge or raft may be built in many ways, the particular system adopted being governed by material to hand in each individual case. As wagon-cloths form part of the military outfit, and are therefore generally available, these are frequently employed to act as the skin of the float, its framework being built up from light timbers. In some cases the wagon-cloth is laid out flat, a heap of brushwood piled in the center of it, and the edges then brought up all around and sewn together at the top (Fig. 2). If this float is to be used in rough water, the seam must be made watertight.

A raft to carry one or two men may be improvised by lashing two long spars to the sides of a cask and connecting them by two planks, the whole thing being stiffened by lashing to upright spars forming rowlocks (Fig. 3). It is usual to propel a raft by means of oars or paddles, but in some cases it is possible to employ the river current to do this. The raft in this case is secured to a long cable which is firmly fixed to a point on the "arrival" bank above the landing place (*a* in Fig. 4). To operate this contrivance, a light line (*b*) is carried across the stream and attached to the lower end of the above cable; the cable is then drawn across to the starting place (*c*), and the raft is secured to it and pushed off into the stream, which carries it down the river until it reaches the "arrival" bank (*d*) and the cable lies parallel with this bank. The cable is then detached from the raft and pulled to the "departure" bank ready for re-attachment on its next journey in the same direction. To return the empty raft a similar cable (*e*) is attached to the "departure" bank. This contrivance is called a "Flying Bridge."



A substitute for a pontoon—a float of tarpaulin over a wooden framework.

* From *The Illustrated War News.*

The Lignite of North Dakota

THE lignite areas of North Dakota occupy nearly all of the western half of the State and are estimated to contain about 35,000 square miles. According to the reports of the North Dakota Geological Survey, there are 97 townships which contain at least one bed of lignite 7 feet or more in thickness, in some places as much as 30 feet. At least 100 other townships contain beds from 4 to 7 feet in thickness. The output decreased from 499,480 short tons, valued at $765,105, in 1912, to 495,320 tons, valued at $750,652, in 1913. Compared with 1911, when the production attained its maximum record (502,628).

At Kenmare, Scranton, and Dickinson lignite is successfully used in the burning of brick, for which purpose its smokeless and sootless qualities and relatively low cost make it adaptable. As the gas-producer and internal-combustion engines in large units come into more general use in the West, as they are rapidly doing in the East, the lignites of North Dakota will be found to possess great potentialities in the settlement and economic development of the State.

In Survey Bulletin 531 Frank A. Herald discusses the possibilities of using North Dakota lignite in the manufacture of briquets, as follows:[1]

"Some briquetting tests have been made with North Dakota lignite and have proved that the fuel can be treated successfully in that way. Tests at the Pittsburgh laboratory of the Bureau of Mines indicate that lignite from the Williston field can be economically briquetted.[2] Lignite from this field has been briquetted successfully at the North Dakota Mining and Experiment Station at Hebron, N. Dak.[3] The Pittsburgh tests were made with high pressure without binder, whereas the others were made with lower pressure and binder. As both methods gave favorable results, experimenters believe that the lignite can be successfully briquetted on a commercial basis both with and without binders. When briquetted the lignite can compete with higher-grade coal, as the briquets withstand weathering and do not crumble badly when handled. The process of briquetting removes 75 per cent of the water in the lignite, thus decreasing the weight about 30 per cent, and considerably increasing the heating value, by saving the heat otherwise needed to remove the moisture. Excessive moisture not only wastes heat during combustion but is also an important factor in freight charges, approximately one-third of the weight of most lignites being water. Briquetting, therefore, is especially useful because it increases the heat value and decreases the cost of transportation. In the tests mentioned above the heat value of the briquets made without binder was about 50 per cent greater than that of the raw material, and the briquets made at the Hebron experimental substation by a different process involving more thorough drying and the addition of binders showed a heat value about 70 per cent greater than the raw lignite."

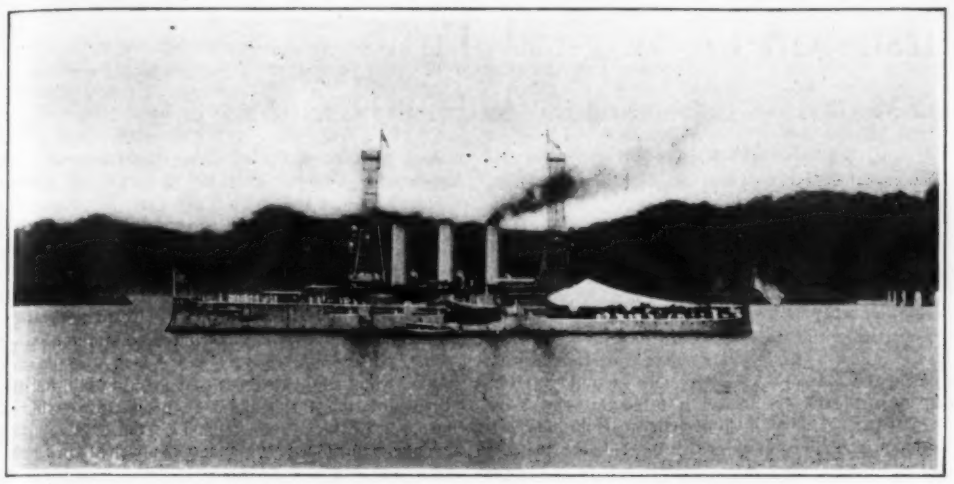
The utilization of lignite, unless briquettes, to be successfully accomplished must be in the vicinity of the mines from which it is taken. When freshly mined North Dakota lignite contains about 40 per cent of moisture. Upon exposure to the atmosphere it gives up a large part of the moisture and then "slacks," or crumbles. Prolonged exposure reduces it to a rather fine powder with probably considerable oxidation and loss of volatile combustible material.

[1] Herald, F. A., The Williston lignite field, Williams County, N. Dak.; *U. S. Geol. Survey Bull.*, pp. 104-105, 1913.

[2] Wright, C. L., Briquetting tests of lignite at Pittsburgh, Pa., 1908-9: *Bureau of Mines Bull.* 14, 1911.

[3] Babcock, E. J., Investigations of lignite coal relative to the production of gas and briquets: North Dakota School of Mines and Exper. Sta. Rept., 1911.

How the German cavalry crosses a river.



U. S. S. "Missouri" passing through Gatun Lake in the Panama Canal.

The U. S. Battleships in the Panama Canal

THE recent passage of the United States battleships through the Panama Canal, on their way to the Pan-Pacific Exposition, while impressive, was by no means sensational as the trip from the Atlantic to the Pacific was accomplished without particular incident or accident. The vessels entered the canal at Cristobal on Friday, July 16th, and the passage was made almost without a halt, except for passing the locks. An interesting feature of the event was a demonstration of the efficiency of the great locks, for, at both Pedro Miguel and at Miraflores, a double lockage was effected, two of the ships going into one of the twin locks together, while the third vessel was accommodated in the adjoining lock. This enabled the ships to maintain fleet order all the way through the canal, and they steamed out into the broad Pacific in proper and orderly formation.

One of the illustrations shows the three vessels in the Pedro Miguel locks, the "Wisconsin" and the "Missouri" in the left hand lock just ready to pass out, while the "Ohio" is in the right hand compartment ready to be lifted. Another picture shows the "Ohio" in the canal, passing the location of the noted Cacarachua slide, which has caused so much trouble and delay in the operation of the canal. The third photograph is of the "Missouri" on her way through Gatun Lake. The safe and rapid passage of these vessels, the first war fleet to make use of the canal, has probably added greatly to the appreciation by the public of the value of this great waterway.

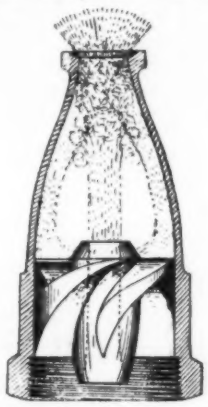
Cooling Water and Air for Power Plants

LARGE steam power plants are frequently erected in places where the water supply is somewhat limited and it then becomes a problem to provide enough water of the right temperature to enable the exhaust steam condensers to be operated satsifactorily, for all large steam motors, whether in the form of reciprocating engines or turbines, are operated on the condensing principle, and require a large quantity of water for the condensers thus a steam turbine requires water at a temperature of not over 103 deg. Fahr. to secure a 26-inch vacuum, and not over 80 deg. for a 28-inch vacuum. Reasonably cool water is also necessary for electric transformers, and for water-jacketed apparatus generally. To meet these requirements it is customary to provide a pond, or reservoir, holding a considerable volume of water, and to return the condenser water to it after use, there being a continuous circulation of the water from the pond, through the condensers and back to the pond, but unless this pond is of considerable size, this circulation will soon raise the temperature of the entire body of water too high for efficient working, unless some special provision is made, especially in summer, and the best method yet devised is to return the heated water from the condenser to the pond in the form of a spray.

Under this system, the cooling of the water is effected in three ways: by evaporation, by radiation, and by convection. That is, heat is abstracted from the water equal to the latent heat of evaporation of the amount of water which evaporates; secondly, heat is radiated from the sprays to the cooler surroundings; and thirdly, heat is carried away by the surrounding air currents by convection. Natural ponds without sprays require about fifty times more area than the spray cooling system and in the summer seldom cool the water sufficiently.

One of the illustrations shows a spray cooling outfit that has been erected in connection with the power plant in the electrification of the Norfolk & Western Railroad, for in this case the river supply would not be sufficient during times of low water. In this picture it will be seen that the spraying nozzles are arranged in groups, and are so inclined toward each other that when the sprays are operating they are caused to collide, and by reason of this collision the drops of water are broken up into much finer particles than could be effected by the nozzles alone. It is evident that by this arrangement much more efficient cooling of the water is effected.

In the second illustration is shown a sketch of a section of one of these spraying nozzles that is widely used, and it will be seen that as the water is given a whirling motion as it passes through the nozzle, the central driving jet impinging on this whirling mass of water ejects it in



Section of a spraying nozzle.

the form of a fine, dense uniform spray. Some such arrangement as this is essential to enable proper spraying to be effected with a low pressure, as it is evidently not desirable to expend any more power on the operation than is necessary.

A second application of the spray system is for washing and cooling air, for instance, for turbo-alternators. The design and construction of the spray turbo air washer are such that every particle of air passing through the machine is forced into intimate contact with fine particles of water from spray nozzles. To insure the complete removal of any dust particles which may have passed through the first set of sprays in the air washer the air is again subjected to the action of cross-scrubbing sprays placed beyond the first set of sprays. The air is next passed through a screen, which removes a large part of the entrained water and prevents any large stratum of air from passing through the washer without coming in contact with wet surfaces. All free moisture in the air is then removed by eliminator plates, the air leaving the washer clean and dry, but with a relative humidity of 100 per cent.

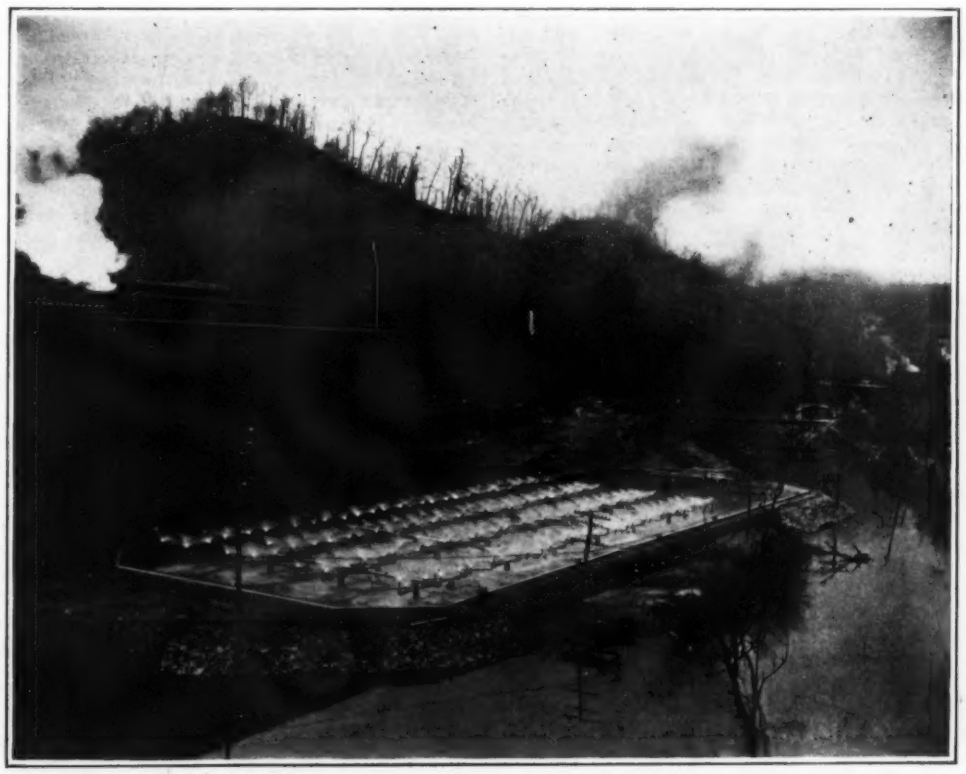
Measurements With the Micropyrometer*

THIS instrument may be used conveniently for the approximate determination of the monochromatic emissivities of metals, oxides, and other substances in microscopic quantities at high temperatures. This method has the further advantages of simplicity and rapidity of operation and also permits the taking of observations on rare elements, alloys, and compounds which are available only in minute quantities. It is possible, for example, under favorable conditions to measure with an accuracy of about 1 per cent the emissivity of a substance having a mass of 0.01 milligramme, an area of 0.25 millimeter, and thickness of 0.005 millimeter. The method lends itself readily to the determination of a temperature co-efficient of emissivity and to the detection of a variation of emissivity with change of state, as at the melting point. The temperature range of the micropyrometer for these purposes is from about 700 to 3,000 deg. Cent.

In the form here used this is a secondary method, requiring a substance of known emissivity as a comparison standard, and for this purpose platinum is taken.

For the determination of its emissivity, a speck of the substance, say 0.01 milligramme, is placed on a platinum strip, or one of iridium or tungsten for substances melting above 1,750 deg. Cent., contained in a suitable atmosphere, as air, hydrogen, or in a vacuum. The strip is heated electrically until the speck melts, when, if observations on the emissivity of the solid are to be taken, the temperature of the strip is immediately lowered below freezing point to prevent alloying. The solid substance should now have a plane, clean surface, and observations of its emissivity in terms of that of platinum may then be taken. For this purpose the micropyrometer, provided with a suitable monochromatic glass in the eyepiece, and for very high temperatures with a calibrated absorption glass before the objective of the microscope, is brought alternately to the same brightness as the platinum strip and the surface the emissivity of which is sought; the apparent temperatures of the surfaces are then measured in succession. With liquid metals observations have to be taken rapidly and before the effects of alloying have reached the surface.

*Bulletin No. 242 of the Bureau of Standards, by G. K. Burgess and R. G. Waltenberg.



Spray water cooling plant for reducing the temperature of condenser water.

An Excursus on Geological Time*

A Review of Various Methods of Estimating the Age of the Earth

I suppose it has happened to most of us, when relating how in past times the mammoth roamed the plains of Holderness, or how coral-reefs once flourished where the Craven hills now stand, to be met by the inquiry: How long ago was that? The answer was perhaps to the effect that geology does not deal with the ordinary measures of time, but has its own system of chronology, not translatable into years and centuries. I must confess, however, to a sense of inadequacy in such a reply, and some sympathy with the lay inquirer who is thus silenced but not satisfied. It seems a matter of reasonable regret that a science which deals with the history of past events should have no definite time-scale, by which those events could be ranged in a correct perspective.

No such reflection, it is safe to say, disturbed the minds of the early Uniformitarians, the founders of modern geology. Their reaction against the older catastrophic school led them constantly to lay great stress on the extreme slowness of geological processes, and they thus came to assume unlimited time for the past changes to which the stratified rocks bear witness. To Hutton there was "no vestige of a beginning, no prospect of an end"; in other words, he regarded geological time as infinite, and could no more contemplate reckoning it in centuries than numbering the sands on the shore. Later this position was reinforced from another quarter, as Darwin's doctrines gained acceptance; for these were held to push back to an immeasurably remote epoch the beginning of life on the globe. Geologists and biologists alike saw no reason for limiting their prodigal drafts on the bank of time.

From this comfortable attitude they were startled, as by a bombshell, some fifty years ago, when William Thomson, afterwards Lord Kelvin, published the first of his contributions from the mathematical side to this and cognate subjects. He pointed out that, apart from any changes on the surface of the globe, our planet, as a whole must be undergoing a change of a secular, and so irrevocable, kind; viz., a continual loss of energy in the form of heat, as proved by the observed temperature-gradient. Since the store of energy cannot be inexhaustible, we must deduce both a beginning and an end of the existing geological *régime;* and Thomson endeavored to set a limit to its past duration from a discussion of the rate of cooling of the globe. A parallel line of argument was based on the cooling of the sun.

Now as regards the validity of the general criticism there can be, of course, no doubt. Huxley's halting defence of what was then the orthodox position was easily broken down, and a wholesome check was given to the extravagance of the geologists. When we turn, however, from the destructive to the constructive part of Kelvin's argument, the case is different. The time to be allowed for the geological record was stated at first with considerable latitude, but was afterwards narrowed down, until, in 1899, Lord Kelvin concurred in Clarence King's conclusion that the globe was a molten mass about twenty-four million years ago. It is rather remarkable that so many geologists were found willing to submit to this narrow limitation. Doubtless they were impressed by the prestige of Lord Kelvin's authority, and perhaps some of them were influenced by a vague feeling that a result arrived at by strict mathematical reasoning is thereby entitled to credence. But, as has been so often pointed out, and so often forgotten, what you get out of the mathematical mill depends upon what you put into it. The reasoning may be unimpeachable, but it merely proves that, if certain assumptions be granted, certain consequences will follow. It may be that Lord Kelvin himself, in the enthusiasm of enforcing his conclusions, did not always recall the foundations on which they rested, and it is to be suspected that many geologists read no more than the conclusions.

Kelvin's argument was based necessarily upon a number of assumptions. At the present time, in the light of fuller knowledge, it is sufficient to note one, which in 1862 seemed little open to question. Kelvin recognized that, while the earth is certainly losing heat, "it is possible that no cooling may result from this loss of heat, but only an exhaustion of potential energy, which in this case could scarcely be other than chemical affinity between substances forming part of the earth's mass." This, however, he dismissed as "extremely improbable," and proceeded on the assumption that heat is the only form of energy to be reckoned with. Since the discovery of radium we have learned that the earth possesses a vast store of potential energy in a highly concentrated form then unsuspected. Strutt has calculated, from data of a very simple kind, that the observed temperature-gradient can be wholly accounted for by radio-activity, if the rocks to a depth of forty-five miles contain as much radium as those at the surface. In other words, the heat generated by radio-active changes within this relatively thin crust will, on that supposition, be sufficient to compensate that lost at the surface. Clearly, therefore, the actual rate of cooling of the globe—if indeed it is cooling—must be far less than that adopted in Kelvin's calculation, and his estimate of the age of the earth must be enormously increased.

This is not all. A study of the various radio-active elements contained in minerals and rocks has shown that it is possible, in certain favorable cases, to calculate directly their age in years. Some estimates of this kind have been made, and the results are liberal enough to satisfy the most exacting claims of what may be called the reformed Uniformitarian creed.

With this turning of the tables one might suppose that the old controversy would come to an end. But the reversal of the situation is, in fact, more complete; for meanwhile there has arisen a formidable minority of geologists who contend, on geological grounds, for estimates of time no more elastic than Lord Kelvin's. The question is still, in great part, one between geologists and physicists, but it is now the geologists who offer us the stinted measure and the physicists the more liberal one.

It is not my purpose to discuss in detail the various geological arguments which have been advanced for limiting the age of the earth to a span of 80 or 100 million of years. The method of procedure is broadly the same in all. A computation is made of the rate at which some fundamental geological process is going on; it may be the lowering of the land-surface by erosion, or its destruction by solution, or the deposition of sediment, or the addition of salt to the sea. Some estimate is then made of the total result of the process throughout geological time. Having the annual rate of increment and the total amount, simple division gives the measure of the time in years. The observational data employed in these calculations are of a very precarious kind, and it would not be difficult to point out instances of that levity in the handling of figures to which I have adverted. But the fundamental weakness of all such reasoning lies in the assumption that the present rate of any of these geological processes can be adopted as equivalent to its average rate throughout the whole time.

The existing configuration of the globe, and all the physical conditions that go with it, have been attained in consequence of a prolonged evolution. If we believe that, as the net result of all its vicissitudes, the land-area has on the whole been growing in extent, in complexity of distribution, in boldness of relief, we must believe also that differences of temperature, of humidity, of climate generally, between different parts of the globe have become progressively more accentuated, and that all geological activities have been quickened as the world has grown older. While there is difference of opinion concerning these *secular* changes, there can be no doubt as regards the great *cyclical* changes which have been repeated several times in the history of the earth: the cycle beginning in each case with an epoch of important crust-movements and including the train of consequences which follow upon this new step in the evolution of the earth. Such a cycle was initiated at an epoch not long remote by geological reckoning, and we are living in consequence in a time of more than ordinary geological activity, with the continental masses rising higher than their average level, and with large tracts of newly deposited strata exposed to the attack of destructive agents.

For these reasons I am of opinion that the present rate of erosion, and of its correlative sedimentation, is much higher than the average rate, and that any calculation based upon it must greatly under-estimate the duration of geological time. I do not ask you necessarily to concur in this conclusion, but at least to suspend judgment in the matter; for it will assuredly be a misfortune if geology, so lately freed from one bondage, should fall straightway into another no less galling. This at least is certain, that every one of the various geological processes which have been discussed in this connection, is controlled by conditions which cause its rate to be very variable. It is a clock which now hurries and now creeps, or stands still, and it can never be trusted as a timekeeper. Even for the most recent chapter of geological history we can make no approach to certainty on these lines. Attempts have been made, for example, to estimate the time since the final retreat of the ice in North America from the rate of recession of the falls of Niagara; but the evidence shows that this rate has varied widely even during the last half-century, and Gilbert, after a careful study of all the data, refrains from offering any opinion on this point.

Must we then abandon all hope of any practicable measure of time in geology? I do not draw this conclusion, but rather that we must search outside strictly geological phenomena for some physical process of which the rate is not affected by any disturbing conditions. There are, I think, only two classes of changes for which so much can be claimed—the transformations of the radio-active group of elements and the astronomical movements. It seems not improbable that in one or other of these two directions the solution of the problem may eventually be found.

The chemists have taught us that radium is derived from the spontaneous breaking up of uranium, the change taking place apparently in two stages and involving the liberation of three atoms of helium. But radium itself disintegrates spontaneously, giving the radium-emanation named niton and liberating another atom of helium. Niton in its turn undergoes disintegration, and so on through a succession of changes. The final product is lead, and in the gradual conversion of uranium to lead eight atoms of helium in all are set free. Of these various spontaneous changes some proceed with extreme slowness, others with comparative rapidity; but in each case there is a constant rate which, so far as experiment has tested it, is independent of temperature or pressure.

Prof. Strutt has shown that this gradual liberation of helium can be made the basis of a method of estimating the absolute ages of minerals and rocks. For example, phosphates and some iron-ores are rich in radium, derived from uranium. They also contain helium, and the ratio of helium to uranium is found to be higher in the older deposits. Estimates of age calculated from these data give high figures: *e.g.* the age of the hæmatite overlying the Carboniferous Limestone in Cumberland is given as 140 millions of years, and even that of the Eocene iron-ores of Antrim thirty millions. The results show some irregularities, and it is, of course, admitted that the method has its own difficulties. If, however, the chief source of error is, as appears probable, the loss of helium by leakage, the figures found will be under-estimates. Helium comes from the thorium series of derivatives as well as from the uranium series, and this is to be taken into account where thorium is found. Zircons from various igneous rocks have also been examined by Strutt, and found to give consistent results as regards the helium-ratio. Mr. A. Holmes has approached the question in a different way, by considering the ratio of lead to uranium in various minerals rich in the latter element. The igneous rocks of the Christiania district, of Devonian age, are in this way calculated to be about 370 million years old. For the Archæan rocks of different countries the estimates range from 1000 to 1600 millions of years. Holmes's results are in general nearly twice as high as those of Strutt; but, if we bear in mind the error due to the escape of helium, which is proved to take place, a discrepancy to this extent is no more than should be expected at this early stage of the inquiry.

The other method which has been suggested for obtaining an absolute measure of geological time is of a more speculative kind, although the principle of it is sufficiently simple. It consists in detecting some clearly marked rhythm or cycle in the geological record, and correlating it with one of the known periodic movements of the earth. It was on these lines that Croll attempted to explain the recurrent glacial epochs; but more to our present purpose is the theory which Blytt has based upon a study of the alternations observed in a succession of sedimentary strata. The most important astronomical cycle of long period is doubtless that which depends upon the precessional movement, by which the relation of Summer and Winter to perihelion and aphelion is gradually changed. This involves a change in the relative lengths of Summer and Winter, and must undoubtedly exercise a marked effect upon climatic conditions, though there is much difference of opinion concerning the exact nature of this effect. Changes of climate may in their turn cause differences in the nature of the sediments deposited successively at a given place, differences which will repeat them-

* From a Presidential Address delivered before the Yorkshire Geological Society by Alfred Harker, F.R.S. Reprinted from the *Proceedings* of the Society.

selves in a cycle corresponding with that of the precession. Probably the most noticeable effect will be a recurrence of limestones and chemical deposits alternating with detrital sediments.

If the matter were no more complex than this, it would be sufficient, where such alternations can be detected, to count them, as we count the rings of growth of a tree, and reckon 21,000 years for each sedimentary cycle, that being the period of the precession corrected for the movement of the perihelion. If the alternations can be distinguished only in some parts of the succession, some hypothesis must be devised to take account of the intervals. Gilbert has discussed in this way a succession of beds, 3900 feet thick, forming part of the Cretaceous system in Colorado. Alternations of calcareous beds with shales come in four times, being separated by unbroken thicknesses of shale. Gilbert calculates for the part of Cretaceous time represented a duration of about twenty million years, with an uncertainty indicated by the number 2 as a "factor of safety."

We have to remember, however, that sedimentation is controlled by other conditions besides climate, and climate depends upon other causes besides the precession of the equinoxes; and, further, that most of these contributing causes cannot be described as periodic in any intelligible sense. There is, it is true, a second astronomical movement to which both Croll and Blytt has made appeal, viz., the variation in the eccentricity of the earth's orbit. This goes through a period of about 90,000 years; but there are considerable irregularities which repeat themselves in the course of 1,450,000 years, giving a larger cycle which embraces sixteen of the smaller cycles. The change of eccentricity must modify the effect of the precessional movement; but Blytt argues that it will also react on the ellipsoidal shape of the globe itself, and so give rise to a displacement of shore-lines. He claims to have traced this effect, as well as the climatic cycle, in such cases as the succession of the Tertiaries in the Paris basin and the Isle of Wight. His conclusion is that Tertiary time comprises two of the larger cycles, i. e., about three million years.

It has usually been assumed that the year is too short a period to leave any recognizable mark on the geological record. This is probably true in general, but in certain favorable circumstances it may perhaps be possible to count annual layers of sediment. De Geer has recently attempted this in the case of certain finely laminated clays of late Glacial and post-Glacial age in Sweden. The material was brought down by sub-glacial streams at a time when the ice had retreated to the higher ground. Consequently the seasonal variations were strongly marked, and the accumulation of sediment was rapid enough to yield an appreciable thickness in each year. From such data De Geer has estimated that the recession of the last ice-sheet occupied a duration of about 5000 years; and he further gives 7000 years as the lapse of time since the recession of the ice.

As regards the longer astronomical cycles, it is clear that the argument involves a large element of hypothesis, and its application, as Blytt allows, is beset with practical difficulties. It possesses a special interest as lending a new significance to the details of stratigraphy, but as a means to the establishment of a geological chronology its value is at present only potential. The radium method of evaluating geological time seems to offer more immediate promise.

In conclusion, it is pleasant to note how these applications of chemistry, astronomy, and meteorology, not merely to general principles of geology but to a definite geological problem, emphasize the fundamental unity of the sciences, and illustrate the powerful aid that may be rendered by one to another.

Rank of Coal-Producing States

In the following table the States are arranged according to their rank as coal producers—first, in the quantity of coal mined, and second, in the value of the product.

In the quantity of coal produced the first nine States held the same relative positions in 1913 as in 1912, but in the value of the product West Virginia, for the first time in its history, outranked Illinois. Kentucky superseded Alabama as fifth in rank of production in 1912 and maintained the lead in 1913, but the latter State remains fifth in the value of the product. Iowa, in 1913, displaced Wyoming in tenth place in the quantity of coal mined, and Kansas displaced the same State in value. Washington went ahead of New Mexico in quantity produced and Utah supplanted Montana. In the value of the product Virginia advanced from fifteenth to thirteenth place, displacing Oklahoma and Missouri, and the last State was also outranked by Tennessee. In the combined production of anthracite and bituminous coal in 1913 Pennsylvania was credited with 46.6 per cent of the total for the United States in quantity and 51.1 per cent in value, both being slight gains over 1912, when these percentages were, respectively, 46.1 and 50. West Virginia's percentage of the total quantity was about the same in 1912, but showed an increase of from 9 to 9.5 in the percentage of the total value. Illinois's percentage of the total output decreased from 11.2 in 1912 to 10.8 in 1913, with a decrease in the value from 10.1 to 9.2 per cent. Ohio's percentages in both quantity and value were about the same in both years, as were also those of Alabama. Kentucky's percentage of quantity increased from 3.1 to 3.4, and of value from 2.4 to 2.7.

RANK OF COAL-PRODUCING STATES IN 1912 AND 1913, WITH QUANTITY AND VALUE OF PRODUCT AND PERCENTAGE OF EACH.—Continued.

1913.

Production.				Value.			
Rank.	State.	Quantity (short tons).	Percentage of total production.	Rank.	State.	Value.	Percentage of total value.
1	Pennsylvania:			1	Pennsylvania:		
	Anthracite	91,524,922	16.1		Anthracite	$195,181,127	25.7
	Bituminous	173,781,217	30.5		Bituminous	193,039,806	25.4
2	West Virginia	71,308,982	12.5	2	West Virginia	71,872,165	9.5
3	Illinois	61,618,744	10.8	3	Illinois	70,313,605	9.2
4	Ohio	36,200,527	6.3	4	Ohio	39,948,058	5.3
5	Kentucky	19,616,600	3.4	5	Alabama	23,083,724	3.0
6	Alabama	17,678,522	3.1	6	Kentucky	20,516,749	2.7
7	Indiana	17,165,671	3.0	7	Indiana	19,001,881	2.5
8	Colorado	9,232,510	1.6	8	Colorado	14,035,090	1.8
9	Virginia	8,828,068	1.5	9	Iowa	13,496,710	1.8
10	Iowa	7,525,936	1.3	10	Kansas	12,036,292	1.6
11	Wyoming	7,393,066	1.3	11	Wyoming	11,510,045	1.5
12	Kansas	7,202,210	1.3	12	Washington	9,243,137	1.2
13	Tennessee	6,903,784	1.2	13	Virginia	8,952,653	1.2
14	Maryland	4,779,839	0.8	14	Oklahoma	8,542,748	1.1
15	Missouri	4,318,125	0.8	15	Tennessee	7,883,714	1.0
16	Oklahoma	4,165,770	0.7	16	Missouri	7,468,308	1.0
17	Washington	3,877,891	0.7	17	Maryland	5,927,046	0.8
18	New Mexico	3,708,806	0.7	18	Montana	5,653,539	0.7
19	Utah	3,254,828	0.6	19	New Mexico	5,401,260	0.7
20	Montana	3,240,973	0.6	20	Utah	5,384,127	0.7
21	Texas	2,429,144	0.4	21	Texas	4,288,920	0.6
22	Arkansas	2,234,107	0.4	22	Arkansas	3,923,701	0.5
23	Michigan	1,231,786	0.2	23	Michigan	2,455,227	0.3
24	North Dakota	495,320	0.1	24	North Dakota	750,652	0.1
25	Georgia	255,626	0.1	25	Georgia	361,319	0.1
26	Oregon	46,063		26	Oregon	116,724	
27	California and Alaska	26,911		27	California and Alaska	95,173	
28	Idaho and Nevada	2,177		28	Idaho and Nevada	5,285	
	Total	570,048,125	100.0		Total	$760,488,785	100.0

—*Mineral Resources of the United States, 1913, United States Geological Survey.*

RANK OF COAL-PRODUCING STATES IN 1912 AND 1913, WITH QUANTITY AND VALUE OF PRODUCT AND PERCENTAGE OF EACH.

1912.

Production.				Value.			
Rank.	State.	Quantity (short tons).	Percentage of total production.	Rank.	State.	Value.	Percentage of total value.
1	Pennsylvania:			1	Pennsylvania:		
	Anthracite	84,361,598	15.8		Anthracite	$177,622,626	25.6
	Bituminous	161,865,488	30.3		Bituminous	169,370,497	24.4
2	West Virginia	66,786,687	12.5	2	Illinois	70,294,338	10.1
3	Illinois	59,885,226	11.2	3	West Virginia	62,792,234	9.0
4	Ohio	34,528,727	6.4	4	Ohio	37,083,363	5.3
5	Kentucky	16,490,521	3.1	5	Alabama	20,829,252	3.0
6	Alabama	16,100,600	3.0	6	Indiana	17,480,546	2.5
7	Indiana	15,285,718	2.8	7	Kentucky	16,854,207	2.4
8	Colorado	10,977,824	2.0	8	Colorado	16,345,336	2.4
9	Virginia	7,846,638	1.5	9	Iowa	13,152,088	1.9
10	Wyoming	7,368,124	1.4	10	Wyoming	11,648,088	1.7
11	Iowa	7,289,529	1.4	11	Kansas	11,324,130	1.6
12	Kansas	6,986,182	1.3	12	Washington	8,042,871	1.2
13	Tennessee	6,473,228	1.2	13	Oklahoma	7,867,331	1.1
14	Maryland	4,964,038	0.9	14	Missouri	7,633,864	1.1
15	Missouri	4,339,856	0.8	15	Virginia	7,518,576	1.1
16	Oklahoma	3,675,418	0.7	16	Tennessee	7,379,903	1.1
17	New Mexico	3,536,824	0.7	17	Maryland	5,839,079	0.8
18	Washington	3,360,932	0.6	18	Montana	5,558,195	0.8
19	Montana	3,048,495	0.6	19	Utah	5,046,451	0.7
20	Utah	3,016,149	0.6	20	New Mexico	5,037,051	0.7
21	Texas	2,188,612	0.4	21	Texas	3,655,744	0.5
22	Arkansas	2,100,819	0.4	22	Arkansas	3,582,789	0.5
23	Michigan	1,206,230	0.2	23	Michigan	2,399,451	0.3
24	North Dakota	499,480	0.1	24	North Dakota	765,105	0.1
25	Georgia and North Carolina	227,703		25	Georgia and North Carolina	338,926	
26	Oregon	41,637	0.1	26	Oregon	108,276	0.1
27	California and Alaska	11,333		27	California and Alaska	26,441	
28	Idaho and Nevada	2,964		28	Idaho and Nevada	9,313	
	Total	534,466,580	100.0		Total	$695,606,071	100.0

Electrolytically Produced Hypochlorites

It is stated in *The Engineer*, in relation to the electrolytic plant at Poplar, that the hypochlorite of magnesia solution is prepared by the electrolysis of water, containing certain definite proportions of sodium chloride and magnesium chloride. In spite of adverse criticisms, the process has been a success for eight years. Hypochlorite of magnesium belongs to the magnesia and not to the alkali group; it is not caustic, is non-poisonous, and to the clothes is the least destructive of all the hypochlorites. It is obvious that the stable solutions of electrolytically-made hypochlorites of magnesium are preferable to those of sodium and potassium or even calcium, because for the purpose of rendering the three last-mentioned solutions stable there would have to be used hydroxide of the alkali metals or calcium, which are extremely caustic, alkaline, and very soluble, and where varying strengths of electrolytic fluid, containing the hypochlorites of sodium and potassium, are produced, one may add too much or too little of the hydroxides of the alkalis when working with unskilled labor. But, when the extremely insoluble hydroxide or oxide of magnesium is added and mixed, one can add and stir in any quantity, but only the necessary amount will be absorbed.

An Australian railroad official has been making a comparison of the English method of connecting railway cars by screw couplings with the American automatic couplers; and he finds the former much more comfortable—American trains being jerky when starting and stopping, especially on night trains. More extended experience would have convinced him that the engineers are largely responsible for, either intentionally or from indifference, they are notoriously rough in handling night trains.

The Government Uses Motion Pictures*

By C, J. Blanchard

THE value of the moving picture has been recognized for several years but the Government has been rather slow in adopting it in connection with its publicity work. Last year, there was a general awakening and under the impetus of a big National exhibit at San Francisco, the bureaus of several executive departments set their operators at work with the result that many thousands of feet of film were exposed and a comprehensive exhibit of Federal Activities in motion pictures is now available. The Reclamation and Forest Service Bureaus, for several years, have been collecting negatives, both still and moving, illustrating progress and development, all of which have proven of value in educational work. The pictures showing the engineering work of road building, construction of huge dams, excavation of tunnels and canals, modern and scientific methods of forestry and lumbering and the use of new machinery in placing concrete, have been widely used and have resulted in increased efficiency on all works under way.

On several of the irrigation projects, where important work is in progress, the camps have been provided with a theatorium and evening picture shows are given, open to employees and their families. The small admission charged has sufficed to return all expenditures for films and equipment. These entertainments have provided amusement and relaxation for the employees located as they are, far from the cities and cut off from the enjoyments of the towns.

They have served another purpose to those actually engaged upon the work, enabling them to study the methods of other engineers. They have stimulated the men with greater zeal in their work and have encouraged the development of new and original plans for labor-saving devices. The plan of exchanging films between projects has familiarized the men with all the work and has resulted in speeding up their own activities.

Arrangements are made with reputable film exchanges for the latest and best dramas and educational subjects so that the usual entertainments are as good as those given in the large cities.

Last summer, with funds contributed from the Exposition appropriation and by civic associations and railroads, I laid out a western trip covering about 17,000 miles of Reclamation territory and including subjects on Indian Reservations en route. I was accompanied by our official photographer, Mr. H. T. Cowling, with a full photographic equipment of cameras, films, etc. Nearly 20,000 feet of film were exposed and about 800 negatives of still pictures were taken. We were quite fortunate in having good weather throughout most of the trip and secured excellent films and photographs.

Our first stop was the Rio Grande Valley, New Mexico-Texas, and our subjects covered an area about 120 miles long. Our experience at Elephant Butte was somewhat exciting as our movies included a number of spectacular incidents in connection with the construction of the huge dam in the Rio Grande Canyon. Taking pictures from a skip while crossing the canyon on the cableways, 400 feet above the river, furnished some thrills but did not result in very good film owing to the swaying of the car and perhaps also to the nervousness of the operator and those who assisted in holding the camera steady. Standing directly under a 17-ton derrick while it was being swung skyward on the cableways tested our composure, but in this instance, we secured a splendid film.

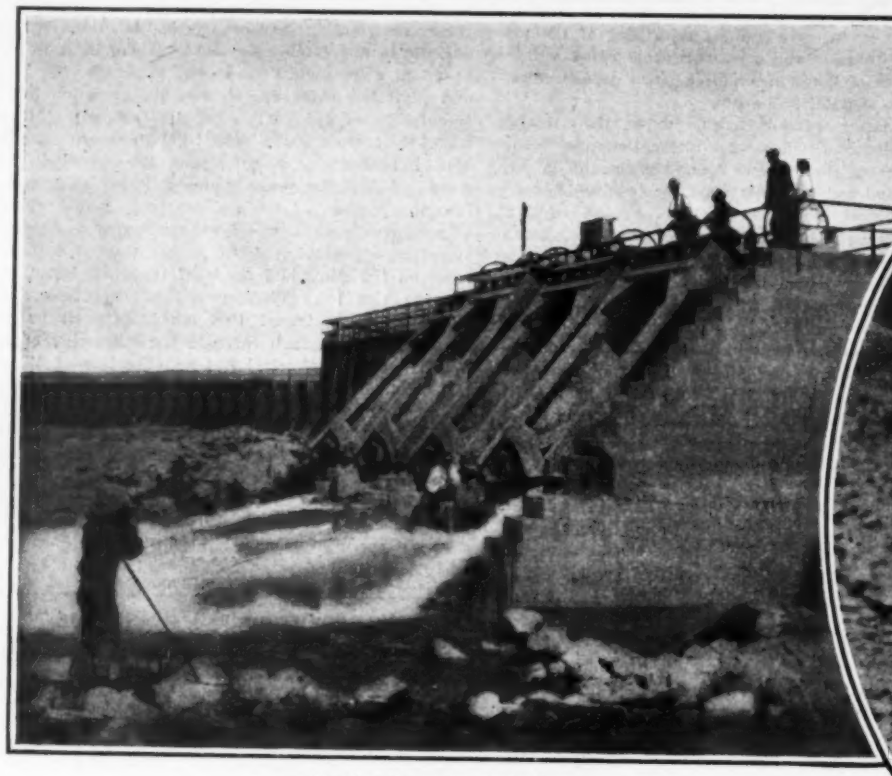
On the Salt River project, we found excitement in taking pictures from a rapidly moving auto on a ticklish piece of mountain road skirting a canyon 1,000 feet deep, and later in a trip across the top of the Roosevelt Dam where the speed limit was overlooked. The camera was tightly strapped to the car and then held in place by two men who clung to the tripod while the operator turned the crank. There were moments when the taking of pictures ceased to interest us, particularly when the car swung sharply on the curves and a chasm, which seemed bottomless, yawned below us.

On the big ostrich farm in the valley, the camera was set up in a lane and 1,000 full grown birds were driven directly toward it. If you have never faced an army like this, you can not appreciate the tremors you feel, particularly when you recall the fact that a Missouri mule has nothing on a full-grown ostrich in the way of a kick. It was a toss up, however, as to which was the more frightened—the operator or the birds.

At Yuma, on the Fourth of July, with the thermometer at 118, we gathered excellent material for our exhibit, in quarry blasts, huge steam shovels and a trip on the new Government railway, down the levees on the Colorado River. A close-up view of the cars dumping rock and the leveller smoothing the levee top gave excellent results. A week later, at Riverside, California, 1,000 feet of excellent film were made at the Indian school. Our subjects here covered the whole institution and showed the Indian boys and girls at work and play.

Five days at the Grand Canyon were productive of

* Republished from *Amer. Forestry Magazine*, Wash., D. C.

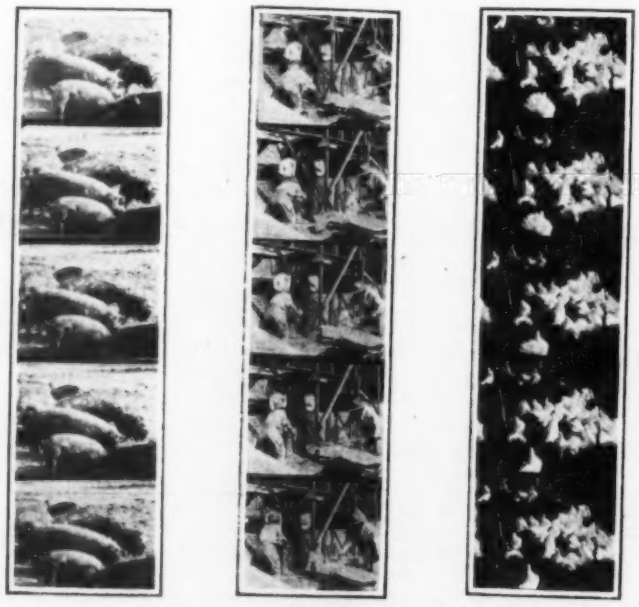


Opening the gates of the dam.

Here the movie operator took a daring chance in order to catch the gush of water when the gates of the Minidoka dam in Idaho were opened.

Peaches—both.

This was the title which Uncle Sam's movie operator thought should be attached to this picture; one of a film, showing fruit growing in the West.



Farm scenes and building operations.

This is on land which once was a barr[e]... bountifully ... products. ...ets of irrig...

The camera was strapped in the ...gh this pi...

UNCL...OVIES

Showing development of a homestead.

The harvesting stage of a homestead settlement drama, which followed the development of the land from a non-irrigated desert to an irrigated and productive farm.

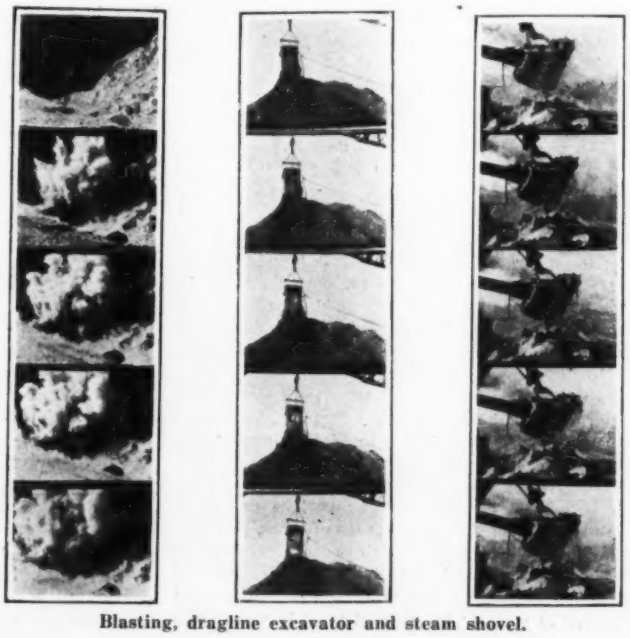
...ountifully produces fine fruit and farm ...roducts. ...rs of irrigation.

...gh this picturesque canyon.

UNCL...OVIES

Moving picture of a round-up.

The operator posted to photograph the round-up of 1,000 Nevada steers on a piece of land irrigated by one of the reclamation service projects.



Blasting, dragline excavator and steam shovel.

some extraordinary film. Here the operator used a filter with splendid results. This great chasm has proven a difficult subject for the moving picture man. The Canyon, which is more than a mile deep, is always partly obscured by a bluish haze which the lens seldom penetrates. The opposite cliffs, nearly a dozen miles away, are usually indistinct and blurred. By using a filter and slackening the speed of the shutter, the distant cliffs and their delicate and intricate carving were sharply revealed, while, at the same time, the towering pinnacles and numerous lesser canyons between were all in view.

The Colorado in flood offered a fine subject for the camera, and a touch of excitement for the operator whose pictures were taken while standing on slippery rocks, splashed with the spray of huge waves dashing at his feet. We utilized a number of Hopi Indians to add a touch of life and the picturesque to these views.

In Nevada, we were so fortunate as to be on hand when the last bucket of concrete was placed in the Lahontan Dam, a unique structure with enormous concrete spillways arranged in steps. In addition to numerous farm and crop scenes, our films show an interesting experiment in co-operation. Nearly 100 farmers with teams, cleared and leveled ten acres of sage brush desert for a new school site, the land for which had been donated by Secretary Lane. There is also a round-up of about 1,000 head of steers with a little broncho bucking and bull-dogging thrown in for good measure.

In Idaho, on the Minidoka project, our subjects were varied. Standing on a boulder in Snake River immediately below the Minidoka Dam, the operator focussed on the big Tainter gates and gave the signal to open. A wall of water 10 feet high, shot out like a catapult straight at him, and the spray of the mighty wave as it dashed against the rocks drenched him to the skin. Quick action in closing the gates prevented any more serious consequences of his daring but the picture was fine. There were many interesting views showing caterpillar drag line excavators and scoop wheels lifting water, all electrically operated.

On the Boise project, a number of exposures were made from the top of Arrowrock Dam, which is to be the highest in the world. Perched on a narrow platform 300 feet above the river, the camera was set to show the entire process of placing concrete. An entirely new and exceedingly unique method is employed, the whole presenting an especially fine subject for a picture. From a large mixing plant on the side of the canyon, two huge buckets were in operation, loading concrete and then swinging on the cableways to receiving buckets on top of the dam. The receiving buckets, suspended from the cableways, took their loads and discharged them through pipes to various sections of the dam. The pipes were movable, permitting the spreading of concrete to any point within a given radius. By this method 60,000 cubic yards of material go into the structure each month. One piece of film was made from the Government train which carried us through the big camp and into the steep walled canyon. All the views were impressive as this great structure is to be the most spectacular work ever undertaken for irrigation in this country. It will be 350 feet high and 1,200 feet long on top, and will contain 500,000 cubic yards of material.

In Colorado, our views were mostly crop scenes. We were fortunate in being in the Uncompahgre and Grand Valleys during the fruit picking season, and excellent orchard views resulted.

In Montana, the scenes on the Lower Yellowstone and Huntley projects were of crops. The harvesting of sugar beets furnished an excellent subject.

Encouraged by our successes on other projects, when we reached the Shoshone project in Wyoming, we determined to enter the dramatic field. Accordingly, we devoted some time in staging a Reclamation photoplay, the characters for which we had to seek on the project. Westerners, you know, are versatile. It was no trick at all to round up the very people we needed, although the full cast called for no small amount of talent. Our drama, founded upon fact, is the story of a settler who takes up a Government farm. The heroine, a school teacher from Illinois, decides to quit her job and ventures into the new West. She, too, locates a farm and hires her neighbor, the bachelor homesteader, to put it into crops. Through the various steps of making the desert blossom, there runs a vein of romance and a touch of tragedy for the heroine's home is burned down during her absence. The betrothal comes when the young farmer tries to comfort the heroine in her loss. The film, in progressive steps, shows the desert, plowing, leveling, irrigating, seeding, harvesting, and threshing, and in the final chapter, two years later, in the new home, there is a baby.

These films are to be shown in daily lectures at the Panama-Pacific Exposition and should serve to acquaint the public, not alone with the activities of the Service, but also the opportunities for homemaking in the West.

After the Exposition is over, they will be useful in the lectures which have become an important function of the publicity work of the Reclamation Bureau.

The War and Navy Departments are entitled to special mention in connection with the utilization of the moving picture. Orders are about to be placed for more than 100 projecting machines which will be installed in numerous forts, in the field and on several battleships. Soldiers and sailors are to enjoy the same films which to-day are viewed in every city and town in the world, the service to be obtained through the regular exchanges. Films will be used also for educational purposes in connection with the training and fitting of the men for their various duties.

Excellent film was obtained last summer by several bureaus of the Department of Agriculture, by the Bureau of Mines, the Geological Survey and Life Saving Service. The activities of the Government in Alaska are quite fully portrayed on several thousand feet of film.

The presentation of these films at the Panama-Pacific Exposition, and later, before popular audiences throughout the country is bound to make the general public more familiar with our Government and its many active functions.

The Therapeutic Uses of Preparations of the Ductless Glands—I*

Notes on Experimental Investigations of Undoubted Future Value

By Robert G. Torrey, M.D.

In the recent work in the realm of physiology there are few efforts which stand out as possibly of striking importance. Some years ago the theory of anaphylaxis was advanced by Poirtier and Richet, and their hypotheses have to a large extent been supported by subsequent investigation. The benefit already attained by the practical application of their theories is incalculable. More recently the work in the von Noorden clinic, particularly by Eppinger and Hess, holds a wealth of suggestion and has already borne fruit in the clinical field. Countless investigators are now working on the problems presented by the ductless glands—their interrelationship and the physiological effect of their activity in health and in states of disturbed function. The relationship of the ductless glands to the nervous tone is not as yet well understood. It seems definitely established that the pancreas produces an internal secretion which acts as a sympathetic depressant; that the chromaffine system as a whole acts as a sympathetic stimulant, or at least as an activator of certain portions of the system; and that the thyroid and hypophysis both in some way inhibit the activity of the pancreas in its nervous effect. This whole subject is so shrouded in doubt, however, that the theoretical side will not be considered here, this paper being limited to a discussion of the therapeutic experimentation which is being attempted with the ductless gland preparations.

Much of this work is pure speculation, much of it doubtless altogether useless, but time and experience will certainly extract some facts which are valuable and which can be shown to rest on a solid foundation. In attempting to put these theories to practical therapeutic use, the broadening of the field of endeavor depends on the practicing physicians. Those who are acquainted with these theories will be on the alert to recognize many interesting conditions which would otherwise escape observation.

THE ADRENAL GLAND.

The adrenal gland or suprarenal body is of all the glands the one about which the most accurate information has been acquired. The isolation of an active principle of a definite chemical nature has made possible experimental work which is more exact than is usual in dealing with animal substances.

The suprarenal body is composed of two portions, morphologically, chemically, and physiologically distinct. The medullary portion contains chromaffine cells related to the nervous system, while the cortex contains cells which stand in relation to certain cells of the sex glands. It is possible that in administering extracts or preparation of the suprarenal gland we have two distinct effects produced—one the result of a medullary substance which activates or stimulates the terminals of the sympathetic nerves. Most of the known action of the glandular extract can be attributed to this factor, including vasoconstriction, hyperglycemia or glycosuria (due to action on the sympathetics of the liver), pupilary reaction, and relaxation of the bronchi. Apart from this action, which may be directly chemical in nature, we have to consider the action of the cells of the cortex.

Animal experimentation is a rather uncertain index of the physiological effect of adrenalin on the human being, as the results of its administration vary a great deal in different species; also the effect is subject to wide variation, depending on many factors, such as nerve depression, as by drugs, muscular relaxation, etc. For instance, adrenalin will cause a marked contraction in a vessel which is relaxed or dilated, while if the vessel is already in a state of good tone there will be little or no effect shown. A small dose may produce a result entirely different from that produced by a larger dose.

As is well known, in the human body adrenalin administered intravenously causes a marked but transient rise in blood-pressure due to contraction of the peripheral arteries. It does not, however, constrict the coronary arteries, but probably dilates them. Its effect on the heart depends on the activity of the vagus, and this is an important factor in determining the extent of the blood-pressure rise. The bronchi are markedly relaxed by its action, and peristalsis and digestive activity are decreased. The mobilization of sugar is increased with a resulting hyperglycemia or glycosuria. Cannon calls the service of the adrenal secretion to the organism an emergency function, increasing the efficiency of fatigued muscle and decreasing the clotting time of the blood. He also points out that strong emotional disturbances stimulate the discharge of epinephrin, continued worry leading to exhaustion and insufficiency of the gland.

In therapeutics its chief employment has been as a local vasoconstrictor, particularly in dealing with the membranes of the nose and throat. Injections of adrenalin have been found very useful in combating the vascular relaxation incident to shock, and while its action in this regard is very brief, it may prevent collapse in emergency. It is of value as a palliative measure in certain asthmatic affections, when an injection of from three to ten minims of the one-to-one-thousand solution either into a vein or deep in a muscle may terminate an attack almost immediately. While it gives prompt temporary relief in a number of these cases of bronchial asthma and of so-called cardiac asthma, it seems to have no permanent curative effect; but fortunately the susceptibility to the drug is not lost by repeated use, and increased dosage does not appear to be necessary. In antitoxin rashes, which are sometimes of serious moment, particularly if accompanied by edema of the glottis, it has been shown that an injection of adrenalin may altogether relieve the patient of symptoms within five or ten minutes. Here again the effect is not permanent and repeated doses may be necessary. I have seen acute circumscribed edema of the lip and of the tongue practically disappear within ten or fifteen minutes after the injection of ten minims of adrenalin solution into a vein on the back of the hand.

Adrenalin is recommended in the vomiting of pregnancy. Zuloaga has continued the administration of adrenalin in severe and otherwise uncontrollable vomiting from the second month of pregnancy to term, starting with ten drops every eight hours and later giving five drops every twelve hours, alternating with calcium. He is enthusiastic regarding this treatment.

Cavazzani has collected forty-seven cases in which a cure of osteomalacia is claimed to have been effected by systematic adrenalin treatment. He refers particularly to the assumption that deficient functioning of the adrenals interferes with normal skeletal growth, and discusses the question of etiology of rickets in this connection.

In the preparation termed adrenalin we have to deal with not only the chemical substance adrenalin or epinephrin, the product of the medullary cells, but also with an extract of the cortical cells, the nature and functions of which are totally distinct from those of the medullary portion of the gland. In some lower forms of life the so-called interrenal body, which corresponds to the cortex of the suprarenal gland in the higher animals, is indispensable to life, while the adrenal representing the medulla of the gland may be removed without fatal results. It is probable that in Addison's disease the destruction of the cortex is largely responsible for the condition, and also the cortex may be in question in osteomalacia and rickets. In the matter of influencing growth and development of the skeletal tissues and of the sex glands, the cortex is probably more important than the chromaffine cells of the medulla.

Many writers have considered the question of a general myasthenia, distinct from but frequently confused with neurasthenia, which is due to adrenal insufficiency and which yields to organotherapy (thyroid, pituitary, and adrenal being recommended).

I have noticed patients showing various grades of general myasthenia, low blood-pressure, poor skin circulation, and slight pains which seemed referred to the heart, who seemed benefited by the dried adrenal gland administered by mouth; also the pituitary gland has seemed of service; but thyroid must in these cases be tried with great caution and carefully watched for bad effects.

In summarizing our present knowledge of the use of the adrenal gland as a therapeutic agent, it may be said that certain immediate and direct actions for which the medullary portion is responsible may be granted; on the other hand, there is probably an action due to cortical substances which has an effect on the nutrition of muscle and bone, and in certain diseases, as suggested, its effect may be sought by gland administration. In Addison's disease, where its use is theoretically indicated, the reports of success with adrenalin are not frequent or convincing.

Adrenalin is generally sold in one-to-one-thousand solution, which is reliable if fresh. It deteriorates rapidly, particularly if exposed to the light. The average dose is from five to ten minims of this solution injected well diluted into a vein or deeply into a muscle. The dried gland is also sold and seems to have a certain value when the cortical effect is desired.

The intravenous use of adrenalin is said to be contraindicated in organic heart lesions, nephritis, and arteriosclerosis. In animals it has been shown by Pearce that it is possible by large dosage to produce arterial degeneration, but its use in the ordinary dose subcutaneously has not to my knowledge been shown to be harmful, even when employed frequently and over long periods, as in cases of asthma.

THYROID.

Next to the adrenal, the thyroid is the gland of which we have the most knowledge chemically, though this knowledge is limited to very narrow boundaries. We know that iodine is a constituent of the gland and that in a measure its physiological activity corresponds to the amount of absorption of metabolized iodine. Iodine is held in combination with the colloid substance of the gland. Whether this combination forms a definite chemical substance is not established. Also the effect of this so-called iodothyrine in hyperthyroidism and Graves's disease is not thoroughly understood. Hyperplastic and hypertrophied glands contain as a rule less iodine than normal glands or colloid goitres. This does not mean, however, that less is present in the system, as the iodine content varies roughly with the amount of colloid substance, while the symptoms produced increase as the absorptive power due to the epithelial elements of the gland increases and with the power of taking up and metabolizing iodine, which seems greater as the epithelial cells are increased.

Different disorders due to variations in the gland are attributed to an excess or lack of combined iodine and the excess of uncombined iodine in the system. Thus iodine poisoning bears a certain resemblance to thyroid disease. Iodine which has been found to be beneficial in endemic goitres is distinctly injurious in acute goitres of the hypertrophic type, giving many of the symptoms of Graves's disease, including gastric and intestinal derangements, tremor, emaciation and muscular weakness. The administration of iodine subcutaneously or by absorption from the skin, will markedly raise the iodine content of the thyroid gland. Administered by mouth its effect seems to be less marked.

Histologically, the normal thyroid gland is composed of acini lined with a layer of epithelial cells. The acini are filled with a colloid substance. In a purely colloid goitre the acini are greatly enlarged, the cells flattened or atrophied, and the colloid greatly in excess.

In cases with a thyroid giving marked Graves's symptoms, we are apt to find a proliferation of the epithelial cells, and, instead of a single layer of lining cells, a thyroid adenoma with papilliomatous outgrowths into the acini and proliferation of the lining layer. This overgrowth later tends toward atrophy. Thus in a patient with enlargement of the thyroid, even with exophthalmos and marked tremor, we may have to deal with a case of hypothyroidism, as truly as though we had a subject of myxedema or a cretin in question.

It is worthy of note that the hypertrophy of the gland may come on acutely and probably as a result of one

* *The Therapeutic Gazette.*

of several influences. Intestinal intoxications, acute infections, certain mineral poisons, also strong emotional strain, all have been shown to be causative factors.

Thyroid activity may be checked by rest (bodily activity greatly augmenting the effect of the secretion); by *x*-ray treatment, which causes a rapid epithelial degeneration and atrophy; and most markedly, of course, by operative removal of a part or the whole of the gland. It is not, however, with this phase of the subject that we have to deal.

The size of the gland is no index of its symptomatic activity. We must remember that an enlarged gland need not mean an overactive gland, and that a relatively small gland may induce marked symptoms. The tendency of all goitres is toward resolution. It may be stated that the tendency of Graves's disease is toward spontaneous cure if the storm of symptoms may be weathered, that normal thyroidism will be reached, but that unfortunately the individual may not without aid weather the storm of symptoms; and further, if the normal point is reached, the condition does not remain stationary at the point of normal secretion, but the patient passes to a condition of hypothyroidism. Were this condition simple and uncomplicated it could easily be identified by the physician, but the bodily structures have suffered during the storm and the circulatory apparatus and nervous and muscular systems all show serious damage, causing symptoms and signs which obscure the picture.

Exophthalmos does not altogether disappear after it is once established. Tachycardia may persist from muscular weakness of the heart, caused by damage to the heart muscle, but the tremor, while it may be noticed, will, however, usually depend on muscular weakness and will disappear under conditions of more or less complete rest.

In considering the milder grades of hypothyroidism we find that signs vary greatly in the adult and in the young, and that there is a difference in appearance depending on whether or not the patient has previously suffered from severe hyperthyroidism which has left permanent damage.

In general, thyroid deficiency must be considered in cases showing mental apathy and muscular weakness with fatigue on slight exertion, particularly if there is no loss of weight. A dry skin and pale appearance point further in this direction. In adults particularly, an enlargement of the thyroid gland which has existed for some time is suggestive. There is faulty metabolism and the carbohydrate tolerance is increased. Albuminuria is frequent. Obesity does not occur with any degree of constancy. Indeed, many extremely thin subjects will be noted, particularly when the hypothyrosis is the result of exhaustion of the gland by a chronic infection or intoxication.

There is reason to believe that in a hypothyrosis there is a deposit of a mucin-like substance, a product of tissue degeneration in all the structures of the body. These deposits of foreign material in the muscle fibres of the heart, in the kidneys and liver, and in the brain and nerves, give rise to a variety of symptoms which may be accounted for on purely mechanical grounds.

Skin affections are very common, as might be expected, the mucin deposits making the blood and lymph supply of the skin insufficient and preventing the action of the sebaceous follicles.

The heart's action may be seriously interfered with and the intestinal tract hampered in its action, producing the digestive symptoms which frequently form such a marked feature of this condition. Kidney disturbance has been accounted for by the same theory. Various neuralgic pains and so-called myositis, also migraine, are encountered in hypothyroid subjects, which yield promptly to thyroid therapy, and which seem explicable on these grounds. By direct observation of the bladder and ureters it has been shown that the administration of thyroid extract has a marked effect in combating congestion of the bladder wall and urethral orifices.

In the young we note occasionally extremely nervous subjects of faulty mental and physical development who are benefited wonderfully by thyroid administrations. Extreme diffidence or sulkiness may be the most marked feature of their condition, or an exaggerated nervousness and almost choreic appearance. Sexual development is delayed. It must be admitted that not all of these symptoms can be established as due primarily to thyroid deficiency, but deficiency in one gland influences other secretions and metabolic activities, and we are describing here a type of case which is favorably influenced by thyroid administration. The use of iodine in inorganic combination does not have a parallel effect, while thyroid medication may influence very strikingly the growth, muscular strength, development and mental capacity. Attention was called by Thompson to the good results following the treatment by thyroid gland in a series of cases of enuresis in children. Following this suggestion, I have noted not only a clearing up of this disagreeable symptom but a remarkable improvement in the general physical and mental condition in several cases.

A case in point is that of a girl of seventeen, referred by a neurologist on account of constant and distressing headaches, general poor health, and menstrual difficulties. This girl was so nervous that it was difficult for her to talk to strangers without attacks of weeping. Menstruation was extremely irregular and accompanied by great mental depression. Enuresis had been frequent for years, and headaches of severe degree were almost a daily occurrence. The use of thyroid in this case was suggested only by the symptoms of enuresis. Not only was this symptom cleared up, but the headaches ceased, and she rapidly improved in her nervous and mental condition to such an extent that she was able to take a business position after completing her studies as a stenographer. I had her under observation for about three years, during all of which time she was more or less dependent on thyroid medication.

In summarizing the condition in which thyroid extract has been credited as an efficient therapeutic agent, we find an alarming long list of diseases and symptoms, but the following demand attention, either through the number of reports of success or by reason of the reputation of the clinician advocating the treatment:

Chronic skin diseases, particularly eczema, psoriasis, and alopecia.

Certain cases of chronic arthritis. Delayed union after fracture.

Anemia, particularly of the chlorotic type, in young women and particularly if associated with metrorrhagia.

Albuminuria, especialy of the orthostatic variety, and in the young.

Enuresis in children.

Menorrhagia. Habitual abortion.

Various mental and nervous conditions, particularly where apathy and depression are marked and where somnolence is a feature. Melancholia, migraine, various neuralgias.

The possibility of thyroid exhaustion and deficiency may be considered in cases showing a chronic enlargement of the gland, or presenting evidence of long-continued infection or intoxication. It must be looked for at some period in most cases of recovery from Graves's disease. The indiscriminate use of thyroid preparation as a treatment for obesity is certainly inadvisable, but the carefully observed administration in the obese subjects will frequently be found to be beneficial.

In thyroid therapy certain rules should be observed, the chief of which is to always start with small doses, and, save in very exceptional cases, to continue with small doses. One-quarter to one-half grain of the dried gland three times daily is a sufficient dose to begin with, and the latter amount may be too large. One effect of thyroid administration is to liberate rapidly from all the tissues the deposits of mucin-like material, and the toxic effect of this flood may be serious if not accomplished gradually. This effect is often mistaken for hyperthyroidism, resulting primarily from the gland administration. The central nervous system and the heart may be seriously affected by this toxic action and the kidneys placed under a severe and sudden strain. As Leonard Williams emphasizes, the greater the need of thyroid extract, the greater the danger in large dosage. Calcium is frequently indicated in connection with thyroid therapy. Children tolerate thyroid well.

The signs of overdosage are easily identified. Tachycardia, flushing, tremor, nervousness, insomnia, and diarrhea are the chief ones. It might be well to say that if after a brief trial of thyroid, carefully administered and closely observed, good results are not apparent, its use should be discontinued. As far as we know its bad results are readily noted, so that a careful and judicious trial of this treatment cannot be said to be contraindicated in any case in which it appears that it might be of value. Patients will be found in whom a hypothyrosis is temporary and in whom treatment may be discontinued. This is particularly so in the young, but in many cases, of course, occasional or continued medication may be required for years.

Thyroid therapy has, I think, been rather generally neglected. In certain suitable cases the favorable results obtained are so striking and so nearly impossible of attainment by other methods that a wider field of experimentation with these preparations should be covered by the practicing physician.

PARATHYROIDS.

The parathyroid glands are small epithelial structures lying in close proximity to the thyroid. They are usually four in number, but accessory glands may be present in different parts of the neck or embedded in the thyriod or thymus tissue.

Their removal results in a prompt onset of general tetany. Their partial destruction causes a condition of latent tetany, which may be chronic and partial as indicated by spastic tendency, or may not become frank until some other condition, such as pregnancy or some physical disorder, supervenes.

The view was accepted for a time that the removal of the parathyroids increased the calcium output and thus decreased the calcium content of the blood and tissues, but this view is now denied by many.

That the calcium metabolism is disturbed in some way is likely, and it is well known that the administration of calcium to patients suffering from tetany will control the symptoms. Other mineral salts, particularly magnesium, are said to accomplish the same result.

The parathyroid is said to have an exciting or stimulating effect on the secretion of the pancreas, an action opposed to that of the thyroid, which depresses the pancreas.

Extracts and preparations of the parathyroid glands have for a number of years been used in tetany and also in paralysis agitans. It is doubtful whether any good results are obtained which could not be produced in a simpler manner by the use of calcium.

The removal or destruction of the parathyroid glands seems to result in an increased excitability of the muscular mechanism of the body. This condition may be controlled to a certain extent by the administration of the gland, or probably more satisfactorily by simple calcium therapy.

Satisfactory evidence is lacking regarding the influence of these glands on growth and development.

(*To be concludcd.*)

Hospital Efficiency.

In May, 1914, the Philadelphia County Medical Society appointed a committee to consider "ways and means by which the efficiency of the hospitals in Philadelphia may be increased." This committee made an extensive study of the hospital situation in Philadelphia. The three reports of the committee embodying the results of this study, together with an introduction on "The Principles of Hospital Efficiency," by the secretary of the committee, are now issued in pamphlet form. One of the most important findings of the committee is that no standards as yet exist by which the efficiency of a hospital may be measured. The operating expense of one institution may be three dollars a day for each patient, and that of another, little over a dollar a day for each patient. Is the latter figure a credit or a disgrace? One dispensary physician may treat twice as many patients in an afternoon as his colleague working under the same conditions. Which one is accomplishing the most good? Standards of efficiency must be formulated and applied before such questions as these can be answered. Naturally, this lack of standards is reflected in chaotic conditions. For instance, the committee made a careful study of the record systems used in sixteen of the largest hospitals in Philadelphia. In eight of these, some systematic effort was being made to secure the completeness and accuracy of the records, the chief resident physician or the registrar finally checking the records. Four different systems of classification were being used in these eight hospitals. Only three of the sixteen hospitals were maintaining separate files for recording all operations performed in the hospital, grouping together all operations of like character, so that the number of all operations performed during a given period, with the results of each, could be quickly ascertained. The committee states that in 31 per cent of the hospitals visited the records were so kept as to be useless for scientific purposes. A number of recommendations are made for the improvement of record systems, the establishing of social service departments, the prevention of dispensary abuses, etc. In fact, *The Journal of the American Medical Association* is of the opinion that the reports contain many valuable suggestions for those who are interested in the improvement of hospitals, and deserves to be widely read.

Foreign Sources of Artificial Dyestuffs

If the general imports of coal-tar dyes into the United States are analyzed as to country of origin, the following is found to be the case for the imports of 1913: Of alizarin and derivatives, Germany supplies 99 per cent; of synthetic indigo, Germany supplies 96 per cent, and Switzerland 2.4 per cent; of other coal-tar dyes, Germany supplies 81 per cent, Switzerland 12 per cent, the United Kingdom 2.8 per cent, Belgium 2.5 per cent, and France 1.0 per cent.

The import from Belgium is supposed to be largely of German origin. The total value of the German import in 1913 was $8,538,000. It constituted 86 per cent of the value of imported artificial dyestuffs.

The Swiss import reached $918,232. It formed 9 per cent of the total value. It will be seen that, apart from the modest contribution of Switzerland, the United States depends almost entirely on Germany for its supply of imported artificial dyestuffs.—*Report of Bureau of Foreign and Domestic Commerce.*

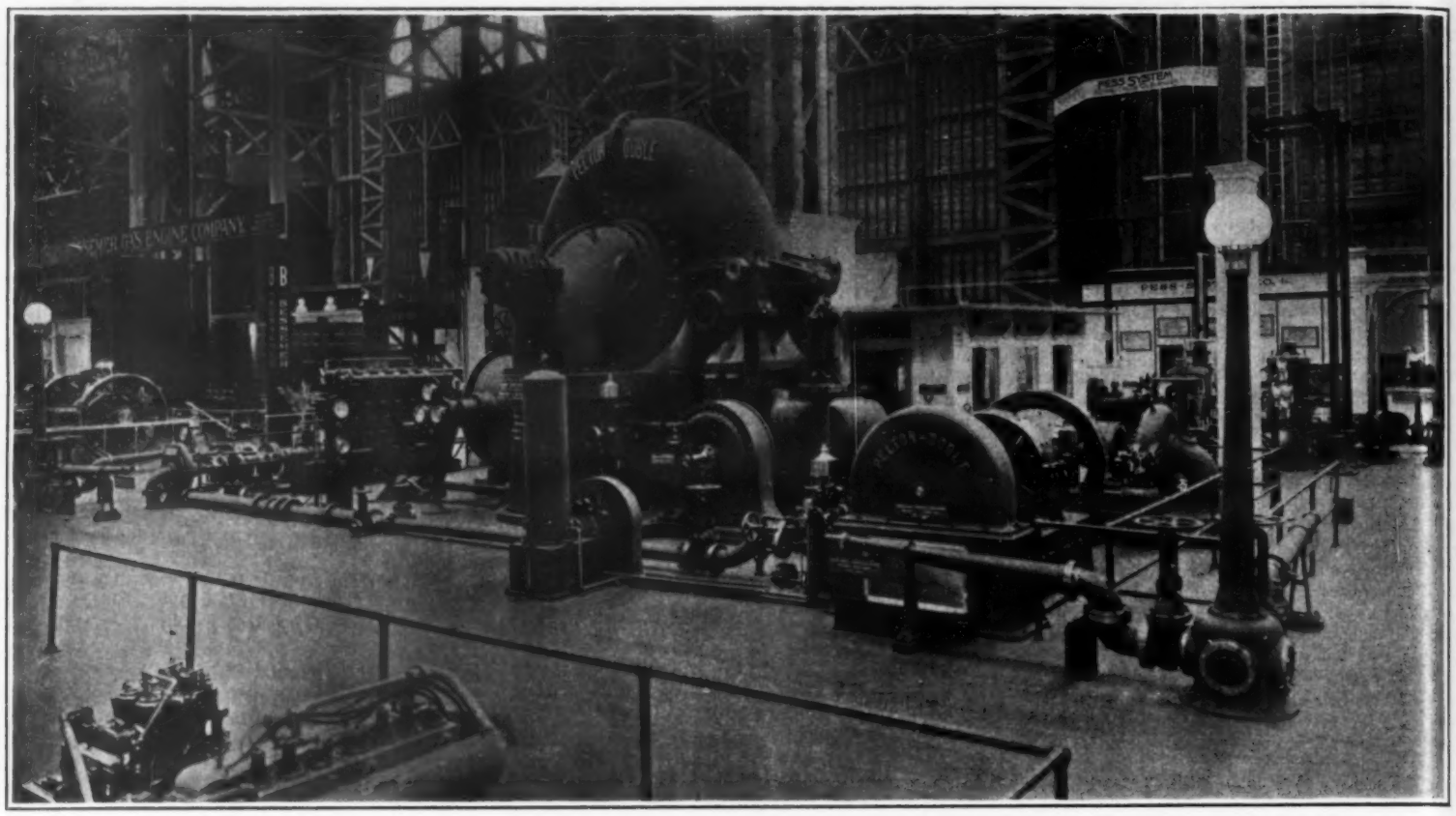


Fig. 1. One of the largest exhibits of hydraulic machinery at the Exposition.

Hydraulic Turbines

Wheels and Pumps at the Panama-Pacific Exposition

By H. J. Kennedy, El. and Mech. Eng.

THE engineer interested in the technical details, and the layman having merely a general interest in hydraulic power development, will both find typical modern practice well illustrated in the exhibit of the Pelton Water-Wheel Company in the Machinery Building, Panama-Pacific International Exposition. The impulse or tangential wheel, often called the Pelton wheel after Lester Pelton (used for heads up to 5,000 feet or more), and the Francis turbine (used for heads up to 500 feet, or even to 700 feet), are illustrated by specimens of different sizes, together with turbine centrifugal pumps, and a lot of auxiliary apparatus, governors, meters, gages, and complete equipment for conducting engineering tests, which were run after the installation of the plant.

Fig. 1 is a general view at southwest corner of the booth, where hydraulic "giants" for hydraulic sluicing or placer mining mark the corners, some of them being used as electric light pedestals. The three main groups of apparatus are: The oil engine, pump, water-wheel generator combination; the big 20,000 horse-power Francis turbine (not operating); and the electric motor-pump Francis turbine-generator combination. The first of these extends along west side of booth from north to south, the water-wheel being in the near corner in Fig. 1; the second is conspicuous in the middle of the west side; the third is on the south side.

Going into detail: Fig. 2 shows the New London Ship & Engine Company's marine Diesel engine, four-stroke cycle, which has six cylinders 9 inches by 12½ inches, develops 180 horse-power at 350 revolutions per minute, weighs 13,000 pounds, and has a 2,000-pound fly-wheel. At the right is the two-stage air-compressor, and near the engine on the left are three steel bottles to hold compressed air for starting and for fuel injection, which have to be strong, as the air pressure is from 700 to 1,000 pounds per square inch. A separate compressor is also provided. The three left-hand cylinders are used for starting by air-pressure, afterward being thrown into action on fuel. The compression in the cylinder is about 450 pounds and the fuel is sprayed in by air pressure, the heat of the compression serving to ignite it.

Near the engine are Foxboro recording instruments for temperature of exhaust gases, pressure of cold water, and temperatures of ingoing and outcoming cooling water.

The power is transmitted through the gearing seen in middle of Fig. 3, to the single-stage turbine centrifugal pump at the left. The herring-bone gearing, which may be seen through a glass window in the case, increases the speed from the 350 revolutions per minute of the engine shaft to the 1,800 revolutions per minute of the pump, efficiency of the transmission being guaranteed at 98½ per cent. The pump, which has a capacity of 1,100 gallons per minute, has a 6-inch discharge, which leads to an eight-inch Venturi meter, which measures, indicates and records the quantity of water flowing at any instant or during any period. This apparatus is seen near the left of Fig. 1.

Fig. 4 shows what may be called a way station or

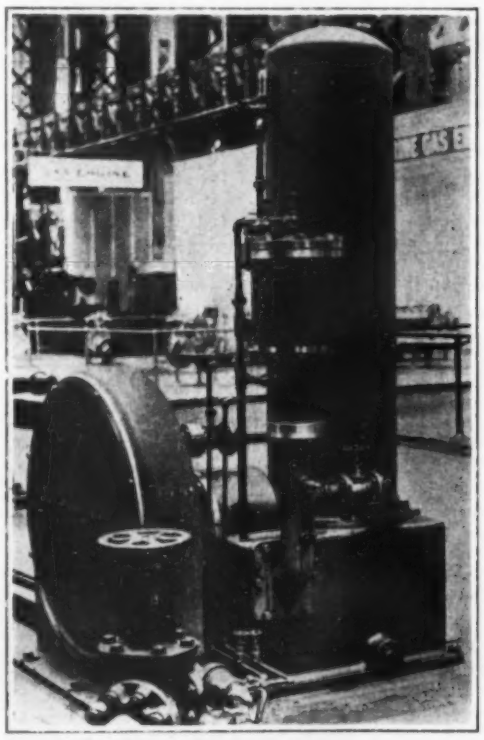


Fig. 4.—A governing device.

spur track on the route of the water from the pump; it is an auxiliary to the governor of the water wheel to which the water is flowing. It consists of the following pieces of apparatus: At the left is a tangential wheel supplied by a branch from the main pipe line. Direct-connected to this wheel is a rotary pump which takes oil from the governor discharge tank and pumps to an established level in the large vertical reservoir at the right. The small chamber in the middle is connected to the large reservoir and contains a float which operates a pilot valve, admitting oil under pressure to the little horizontal cylinder with spade-handle projecting therefrom at bottom of picture. This controls a needle-valve admitting water to the water wheel. This apparatus maintains an approximately constant pressure in the oil reservoir, by allowing the level of the oil and the volume of the air above it to vary only within certain limits. Thus the governor of the main wheel is automatically kept supplied with oil at uniform pressure.

The main wheel is shown in Fig. 5, being a Pelton-Doble tangential water wheel, 100 horse-power, at 300 feet head (maintained artificially, of course, by the pump shown in Fig. 3), and 300 revolutions per minute, controlled by a Pelton-Doble oil-pressure governor, with auxiliary relief or by-pass nozzle, the operation of which is as follows:

The main or power nozzle is that near the hand-wheel in middle of picture. Below it is an auxiliary or by-pass nozzle. The mechanical connection between the needles of these two nozzles is ingenious and results in regulating the flow of water striking the wheel with a minimum of waste and without causing injurious shocks in the penstock. The centrifugal governor at the top controls the pilot valve admitting oil pressure to the cylinder above main needle valve; the plunger of this cylinder is connected to the lever at left. Above its fulcrum this lever is connected to the main needle valve. Below its fulcrum it is connected to the auxiliary needle valve through a cataract connection, being directly connected to the piston-rod of the cataract, and the cataract cylinder, itself free to move, being connected to the needle valve.

Suppose that the tangential wheel runs too fast, due to considerable load reduction: The governor partly closes the upper nozzle; and it opens the lower one, because the inability of the oil to flow quickly from one end of the cataract to the other, causes piston and

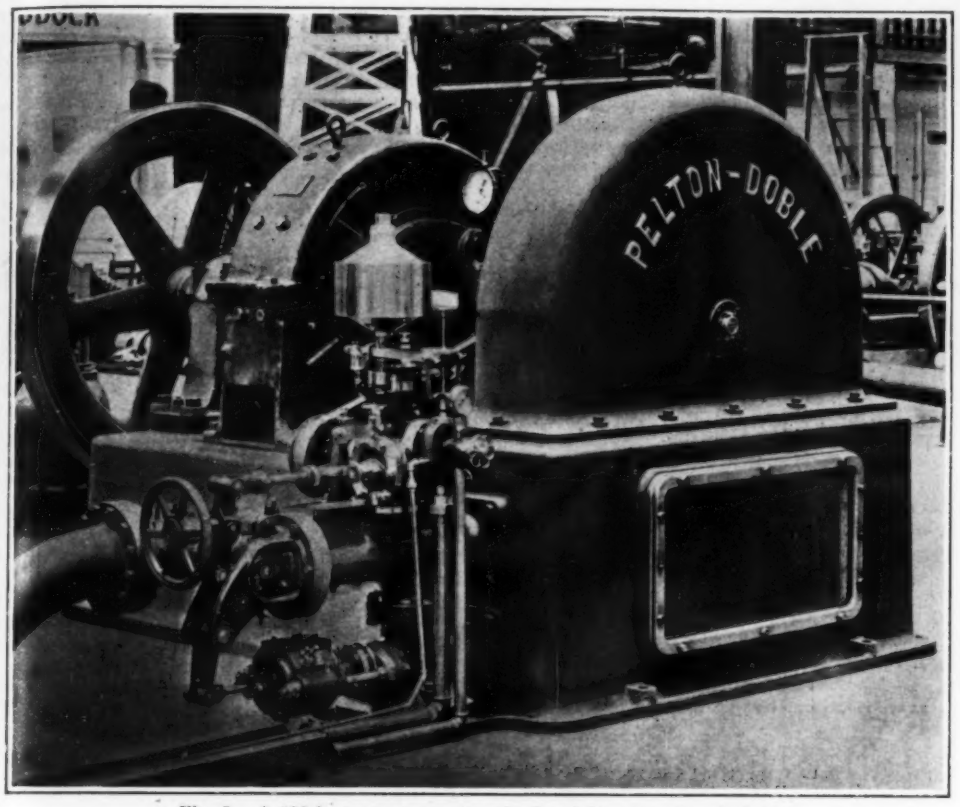


Fig. 5.—A 100 horse-power water-wheel and its governing devices.

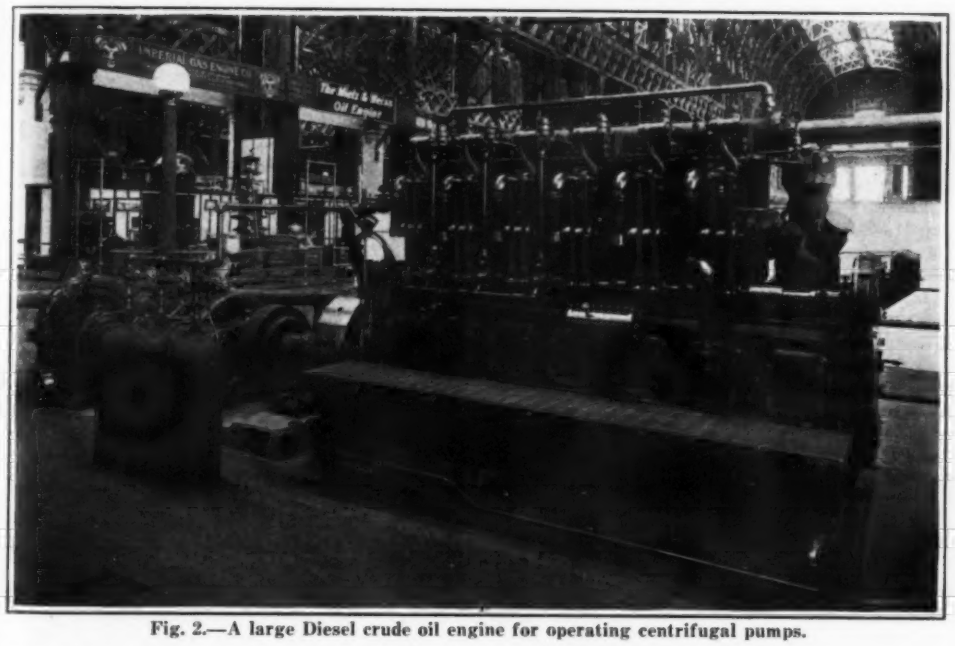


Fig. 2.—A large Diesel crude oil engine for operating centrifugal pumps.

cylinder to move together. However, the tendency of the lower nozzle is to close, and this is accomplished gradually as the oil gets past the cataract piston to the other end of the cylinder. Thus, the quantity of water striking the wheel buckets is instantly reduced without a water hammer or excessive pressure rise in the penstock, and still only a small quantity of water is wasted through the by-pass. This action may be watched through the glass window in the wheel casing (at right in illustration), an electric light within making everything plainly visible, and a mirror (not shown in picture) enabling both nozzles to be watched simultaneously. It is very interesting to watch the action when the load is variable or the head is unsteady; a reduction of load being almost instantly followed by a diminution in diameter of jet from the main nozzle and a squirt for a second or two from the lower nozzle.

The cataract piston can move freely in the opposite direction in its cylinder, due to the construction of the oil check-valve, so that if main wheel requires more water, there is no impediment to the immediate opening of the main needle. The auxiliary needle, of course, remains closed in this case. This is the most advanced type of Pelton wheel governing and makes for maximum economy in water.

This water wheel is direct-connected to a 75-kilowatt, 250-volt, direct-current generator, 300 revolutions per minute, feeding current to the bus at the switchboard in the office. This completes the impulse-wheel group.

Coming next to the large Pelton-Francis turbine, it appears proper to mention the power development for which it was constructed, comprising a series of plants on the South Yuba and Bear rivers in Placer and Nevada counties, California. The ultimate installation at the plant will comprise four 12,500 kilowatt-volt-ampere generators, each driven by a pair of eight to ten thousand horse-power Pelton-Doble tangential water-wheels, under 1,375 feet head, two generating units being now installed and in operation. "Number Five" plant is now under construction, and it will contain one of the generators built for the Drum plant, 12,500 kilowatt-volt-ampere, 6,600 volts, three-phase, 60-cycle, speed 360 revolutions per minute. The electromotive force will be stepped up to 110,000 volts for transmission on the 110-mile line from Drum to the big substation at Cordelia, Solano County.

The speed of this generator and the head, 519 feet static, led to the choice of a reaction turbine to drive it (built to suit the shaft already made), which is the largest single-discharge turbine yet built. The four sections of the large spiral case of turbine are notable steel castings. The vertical cylinder on trunnions seen in Fig. 1 is an oil dash-pot to steady the motion of the rock-shaft that controls the water pressure.

The rock-shaft is operated by a so-called rotary piston in an operating "cylinder" using oil pressure, which cylinder, though set on the floor in the exhibit, will in the power plant be set on a level with the rock-shaft the two horizontal shafts being set in line and connected together by a muff coupling. The "operating piston" is a wing rotating in a certain angle about the horizontal axis.

Immediately in front of the discharge elbow in Fig. 1, is seen the centrifugal governor which initially controls the position of the operating piston. The connecting lever and rod constituting part of the relay return mechanism, may also be seen; by this the operating piston, when it moves, resets the pilot valve (exactly as in a ship's steam steering gear).

The third group is on the south side of the exhibit and illustrates a small Pelton-Francis turbine supplied with water by a centrifugal pump. An interesting group is the 50 horse-power, inward-flow turbine, which operates under 50 feet head at 1,400 revolutions per minute. It is direct-connected to a 30 kilowatt, 250-volt Westinghouse Type SK direct-current generator, supplying current to the buses in the office. An oil-pressure governor operates the wicket gates and cascade valve.

The governors on the impulse wheel, and on the large and the small Francis turbines, each have a little electric motor to permit of remote control from the switchboard.

There is an interesting little hand-operated model of main and by-pass needle-valve mechanism of same principle as that on the 100 horse-power tangential wheel. It is arranged on an actual pipe-line supplied with water, and discharges into a stand-pipe fitted with patented vortex baffle-plate, a most ingenious but simple device for absorbing the shock of waste water, which in a high head plant is almost like artillery fire in its destructiveness.

The pump supplying water to the 50 horse-power Francis turbine is of a type often used in irrigation work, being of the vertical shaft type for insertion into a deep bored well. Its capacity is 4,500 gallons per

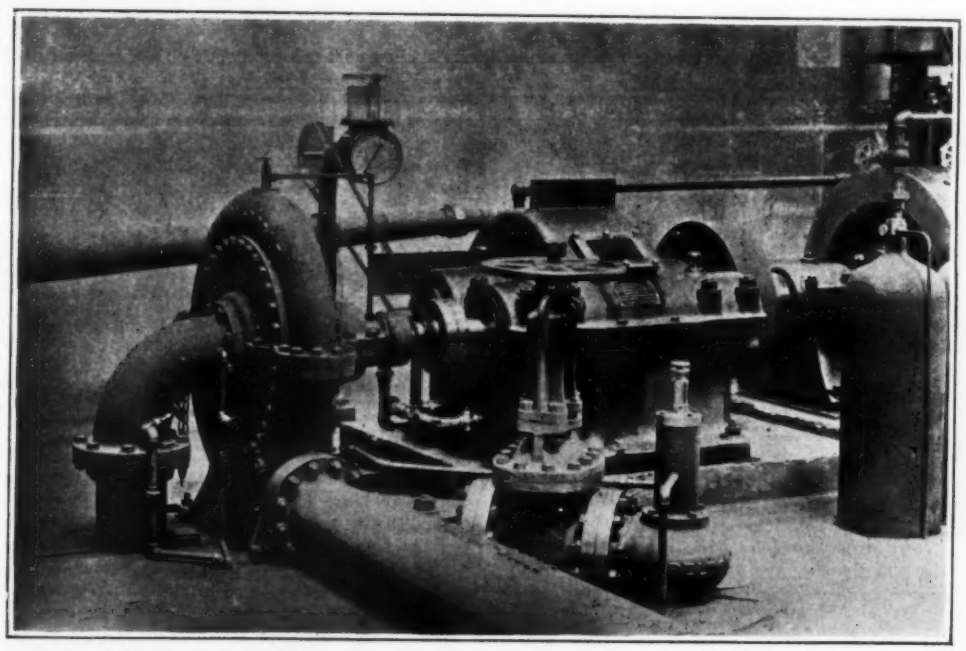


Fig. 3.—Transmission gear between the Diesel engine and a centrifugal pump.

minute at 1,760 revolutions per minute. The single-stage runner supplies 50 feet head to the turbine, drawing water from the tank below floor, into which the water wheels themselves discharge. A Westinghouse Type CS, 100 horse-power, 220-volt induction motor mounted at top of a vertical shaft, drives the pump.

Between pump and turbine is a Builders' Iron Foundry Venturi meter, 18 inch tube, 9 inch throat, for measuring the water.

The other portions of this exhibit are disconnected pieces of apparatus or parts of same. Among these is a three-foot standard Pelton water wheel on wood frame with jet deflector.

Another interesting feature is a bucket from the water wheels for the new San Francisquito plant on the Los Angeles aqueduct, this bucket measuring about 31 inches across the double face. Two runners for tangential wheels to develop 10,000 horse-power each and operate under 1,450 feet head, speed 360 revolutions per minute, weight 12,000 pounds each (the buckets, of course, being bolted on), and a complete needle nozzle for same, are shown separately. Governors, small water wheels, and needles standing on end like highly polished steel obelisks, form other portions of the exhibit, which altogether is an epitome of water-power development, so far as the mechanical end is concerned.

Evolution of the Modern Dry Plate

Its History, Chemistry and Manufacture

By E. P. Wrightman, Ph.D.

It had been observed at an early date that certain silver salts, among them silver chloride and bromide, are sensitive to light. The first observation of this was due to Schulte,[1] in 1727. Beccari did some work on this subject from 1731 to 1757. Further work was done by Scheele in 1777, who found that silver chloride is more sensitive to violet than to red light; he also knew that chlorine was liberated when silver chloride was decomposed by light; but it was not until 1802 that photography, based upon the use of these silver compounds, began. Thomas Wedgewood it was who first obtained light pictures. "They were simply prints of leaves and other such things, prepared by allowing light to fall through a more or less transparent object onto white paper or leather, previously moistened with a solution of silver nitrate and then dipped into potassium chloride." The pictures were, of course, not permanent, because there was no way of "fixing" them known at that time.

Along about the same time, or a few years later, Prof. Charles projected the shadow of a head by means of strong sunlight onto a sheet of white paper made sensitive with silver chloride. He thus obtained a white profile on a dark background. He also was unable to fix his print. It should be said that it was Davy who pointed out to Prof. Charles that the chloride of silver is more sensitive than the bromide (as a matter of fact it is not, but of that later).

The silver image was not the first to be made permanent, although experiments along this line were started as early as 1814 by Joseph Nicephore Niepce. Utilizing the property of certain resinous and bituminous substances on exposure to light, to become insoluble in hydocarbons and other oils which dissolved them freely before, he coated a metallic plate with bitumen, exposed it for several hours in a camera provided with a lens and afterwards "developed" the image by immersion of the plate in oil of lavender.

Daguerre began his experiments on photography in 1824. He and Niepce formed a partnership in 1829 and, although the former discovered the principle of his famous process in 1832, it was not until 1839 that the invention, known by his name, was announced to the world. The French government, by the way, paid him 6,000 francs to publish it. The process consisted of allowing vapors of iodine to act on the polished surface of a silver plate, with the formation of silver iodide. The plate thus prepared was exposed to light for twenty minutes in a camera. No image appeared, however, until the plate was subjected to the action of the vapor of mercury which was deposited in fine globules on the parts of the iodide surface acted upon by the light, the shadows remaining intact as silver iodide. Daguerre first used a hot solution of sodium chloride to remove this, but Sir John Herschel latter pointed out the greater solubility of the haloid salts in sodium hyposulphite, so Daguerre adopted this as his fixing agent. It is interesting to note that, although there have been changes in every other part of the photographic process since Daguerre's time, the use of this substance, sodium hyposulphite (more properly, sodium thiosulphate), or "hypo," as it is called, has held its own right down to the present time.

Simultaneously with the Daguerreotype process in France, another entirely different process was announced in England, in 1839, by Fox Talbot, who presented a paper before the Royal Society on "Pathogenic Drawings." He exposed in a camera a sheet of paper which had been soaked in a weak solution of sodium chloride and afterwards washed with a solution of silver nitrate. The paper was quite sensitive and became black at every point where the light struck it. The image was fixed by immersion in sodium chloride. In turn a number of prints could be obtained from this negative. Two years later, in 1841, a very much improved method was brought out by Talbot and patented as the "Calotype" process. In this, paper covered with a film of silver iodide, formed by first dipping in silver nitrate and then in potassium iodide, was exposed in a camera, with no visible result. The latent image, however, was developed on treating with a mixture of silver nitrate, acetic acid and gallic acid, and fixed with sodium hyposulphite. The negative was rendered transparent by treating with white wax, so that the positives which were obtained from it were a great improvement over the earlier ones. Minor improvements were later made in the calotype process by Talbot himself, and Goddard pointed out, in 1840, that a mixture of the bromide and iodide of silver was much more sensitive than either the iodide or bromide separately.

Prints and negatives up to that time still contained irregularities and imperfections owing to differences in the surface of the paper. These were eliminated to a large extent in 1848 by Banquert Evrard, of Lille, by coating the paper negative with egg albumen; and in 1849 LeGray used gelatine and also waxed his negatives. Niepce de St. Victor, nephew of the old Niepce, about the same time, used glass instead of paper. He coated his plate with egg albumen containing a solution of potassium iodide, and when dry this was sensitized by immersion in silver nitrate. Thus began the so-called "wet plate" photography.

It was about 1850 that modern photography can be said to have begun, when Scott Archer made practical the use of a sensitive *collodion film*, instead of egg albumen, on a glass plate, as suggested by Gustav le Gray in 1850. His method was as follows: A solution of cadmium or zinc iodide, or bromide, was dissolved in collodion, which consists of a solution of the tri- and tetra- (lower) nitrates of cellulose $[C_{12}H_{17}(NO_3)_3O_7]$ and $[C_{12}H_{16}(NO_3)_4O_6]$, in alcohol and ether, and is prepared by treating ordinary absorbent cotton or filter paper (both very nearly pure cellulose) with a *cold* mixture of sulphuric and nitric acids and a little water—if the acids are hot guncotton (composed of the higher nitrates)—is formed. The collodion was poured onto a glass plate and allowed to evaporate. When a photograph was desired, the plate thus prepared was dipped into a solution of silver nitrate, to make it sensitive, and then exposed in a camera. The latent image produced—that part of the film affected by the light—was made visible by treating the plate with ferrous sulphate or pyrogallic acid, to either of which were added some alcohol and acetic acid. The unaltered silver iodide was removed by treating with hypo.

One sees, of course, what a cumbersome process this was. It necessitated the making of the plates on the spot and in a dark room. But even at that it was better than the older processes. A number of men tried to overcome the difficulty by preparing dry collodion plates—Taupenot, working in 1855, was one of these. All attempts at first to dry the sensitive film resulted in failure. The excess of silver nitrate would crystallize and cause flecking, and if washed out the sensitiveness was destroyed. Moreover, the film would not stick to the glass when dry, but would invariably peel. Peeling was finally prevented by coating the plates with albumen or gelatin, or, still better, with a film of Indian rubber dissolved in benzine or chloroform. The excess of silver nitrate having been washed out, however, destroyed their sensitiveness to a large extent. It should be said, however, that the wet process is still extensively employed in modern newspaper photography.

What does the plate really need at this stage to make it sensitive again? Obviously a halogen absorber or reducing agent, one which will only reduce when the plate is exposed to light. Such a "preservative," as it is called—because it also protects the collodion surface—was supplied by the use of a surface coating of albumen, or gallic acid, or tannin. Even when thus treated the plates are far from being sensitive, although the production of an image may be hastened in development somewhat by the use of an alkaline developer, as suggested in 1862 by Colonel Russell.

As early as 1853 Gaudin had suggested the use of "emulsions," so-called, and in 1861 gave details of a process. It did not prove to be very practical. Bolton and Sayce, three years later, finally brought out a successful process, using a silver bromide-collodion emulsion. In 1865 Wharton Simpson likewise used an emulsion *for printing paper*, in this case the chloride, instead of the bromide being used.

This first successful method of making dry plates consisted in the formation of a sensitive collodion emulsion, prepared, not as in the case of the wet plate method, on the glass, but by pouring together an alcohol-ether solution of collodion with an alcoholic solution of cadmium or zinc bromide, and treating this with an excess of an alcoholic solution of silver nitrate, when a very finely divided precipitate of silver bromide is formed and is held in suspension by the viscous collodion. The emulsion must be washed to free from silver nitrate and other impurities. Undoubtedly some of these are retained by occlusion or adsorption so that the sensitiveness of the emulsion is to a certain extent retained. Now comes the critical point in the whole procedure. The emulsion thus prepared must be allowed to "ripen," that is, it must stand until the molecular state of aggregation of the bromide is such as to be most sensitive to light, before it is finally ready for spreading upon the plate. This ripening process will be explained later. In order to make the emulsion stick when dry, a solution of India rubber in chloroform or benzine was sometimes employed. Also a so-called "preservative," which acts both as a sensitizer and as a protective agent, had to be added to the emulsion. Either albumen, gallic acid or tannin was used.

There were two ways of washing employed: film washing, that is, washing after the emulsion had been poured onto the plate and allowed to set; and mass washing, which is washing the emulsion in bulk. The latter method has the advantage that a large quantity can be washed at once and kept for a while without deterioration.

These dry plates, while undoubtedly of great value, and much superior in many ways to what had gone before, were still not entirely satisfactory. They were too slow, indeed, from ten to one hundred times more so than our modern gelatin plates.

Dr. R. L. Maddox, in 1871, was the first to introduce the gelatin emulsion process. This process revolutionized photography. As the name of the process would suggest, the starting point of the modern dry plate is gelatin. "Gelatin is a nitrogenous substance somewhat similar to the proteins, or the meaty part of animal matter, extracted from bone cartilage, connective tissue and skin, by treatment with acids and boiling with water. Little is known of its chemistry." Its empirical constitution, according to Schutzenberger and Bougeois, is $C_{76}H_{124}N_{24}O_{29}$, but of course this gives no idea of its actual constitution. A list, given by Alexander, of the products into which it is decomposed on hydrolysis looks very formidable:

Glyceine, $CH_2(NH_2)COOH$
Lycine, $CH_2(NH_2)(CH_2)_3CH(NH_2)COOH$
Alanine, $CH_3CH(NH_2)COOH$
Phenylalanine, $C_6H_5CH_2CH(NH_2)COOH$
Leucine, $CH_3(CH_2)_2CH(NH_2)COOH$
Aspartic Acid, $COOH.CH_2CH(NH_2)COOH$
Glutamic Acid, $COOH.CH_2CH_2CH(NH_2)COOH$

[1] The darkening of hornsilver on being removed from a mine was first noticed by Fabricius. Also Glauber and Boyle noticed the discoloration of silver salts as early as the sixteenth century, but it was not accounted for as due to light.

Histidine, $N\text{-}CCH_2CH(NH_2)COOH$

$HC\ CH$

$\quad\ NH$

Arginine, $NH:C(NH_2)NH(CH_2)_4CH(NH_2)COOH$

Proline, $H_2C\text{-}CH_2$

$H\ C\ CHCOOH$

$\quad NH$

Oxyproline, $H_2C\text{-}CH.OH$

$H_2C\ CHCOOH$

$\quad\ NH$

"It appears to be resolvable into two forms, one derivable mainly from unhardened cartilage called chondrin, and the other mostly from hardened cartilage known as glutin." It is the latter which is most used in photography. Its properties are very familiar. In contact with cold water it swells, absorbing a considerable portion of the water. If warmed a solution is gradually formed, out of which, on cooling, a gelatinous mass solidifies, more or less firm, according to the amount of the water used. It is slightly acid when fresh, and does not keep long when wet, becoming alkaline, and, in about ten days or so, evolving ammonia. The plate maker must watch, therefore, that his gelatin does not become stale, because in that condition the silver chloride emulsion decomposes even without light.

One method of preparing the emulsion is to bring together into solution the gelatin with potassium bromide, and usually a little iodide. A solution of silver nitrate is gradually poured into this gelatin solution. At first there is no precipitation, then exceedingly finely divided silver bromide particles begin to form. A precaution which must be taken is to have at least just enough potassium bromide present so that there shall not be an excess of silver nitrate, which would act on the gelatin, as it does on any easily oxidizable organic matter in the presence of light, and causes a fogging of the plate when developed, that is, a precipitation of silver other than that of the latent image. In another method a little ammonia is added to the silver nitrate solution which is mixed with the gelatin solution of potassium bromide and iodide. There are other methods than this, of course, each manufacturer of plates probably having his own, but they are all similar in principle.[2]

Just as it was necessary for the collodion emulsion to ripen, the same is true of the gelatin emulsion. The change in ripening is, as shown by Van Monchoven, Eder, Abney, and Vogel, purely a physical one, an increase in the size of the bromide particles. When the silver bromide is first precipitated it is in an extremely finely divided state of aggregation. Micrometric measurements by Eder show the particles to be from eight ten-thousandths (0.0008) to fifteen ten-thousandths (0.0015) of a millimeter in diameter. During the process of ripening a physical change takes place, and the particles increase in size to 0.003 to 0.004 of a millimeter in diameter. Just *why* this increase in size should make the plate more sensitive has never been very satisfactorily explained.[3] It may be due to a change in the absorptive power of the particles, for a change in the optical properties of the emulsion likewise occurs during the ripening. The silver bromide first formed is yellowish white by reflected light and reddish by transmitted light. As the particles grow and become more sensitive they are richer in blue and violet and poorer in red. When ripe the emulsion is gray or grayish violet by transmitted light and greenish by reflected light.

That the ripened emulsion contains the normal silver bromide and not a reduction product, or something else, can be shown by dissolving out the gelatin with water. The precipitate left behind has the composition AgBr. Moreover, it is not acted upon by developer unless there has been exposure to light, or a special reducing agent has been added.

There are several methods of increasing the size of the bromide particles. The first method, used by Bennett in 1878, was to allow the emulsion to stand for a week at about 32 deg. Cent.. (89 deg. Fahr.). Then it was found by Stuart Wortley that by increasing the temperature to 60 degrees only a few hours were necessary for the ripening. Finally, Mansfield, in 1879, found that by bringing the emulsion to 100 deg. Cent., for less than an hour, the maximum sensitiveness was reached. Beyond the point of maximum sensitiveness the particles continue to grow as before, but they then begin to react with the gelatin.

According to C. E. K. Mees, "actually, if we start with a fine-grained emulsion and cook it, the size of the grain and sensitiveness only increase to a certain limited extent." . . . In order to get a high speed emulsion, having larger grains and much greater sensitiveness, we must start in an entirely different manner, precipitating the silver bromide of medium grain, which can then be increased in size with concomitant increase of sensitiveness, and no direct transformation from one to the other seems possible."

What causes the particles to increase in size? The reason given by Meldola seems a satisfactory one. In the emulsion there is a slight excess of potassium bromide. Silver bromide is more soluble in a solution of potassium bromide, especially in the presence of gelatin, than it is in pure water, in which it is almost insoluble, and since there is a silver bromide precipitate present, part of it goes into solution, until the solution becomes saturated. Now if any of the water is evaporated off from this solution, as would happen on long standing, or on boiling, the dissolved bromide would tend to precipitate, as is the case with any saturated solution, the larger particles growing at the expense of the smaller ones, and it does so on the larger nuclei of silver bromide already there. This takes place much more rapidly on heating because not only do you have more rapid evaporation, but also because the saturated solution at higher temperatures contains much more of the dissolved substance than it can hold at lower temperatures. The addition of ammonia to the ripening emulsion, as spoken of above, is very effective, because it dissolves silver bromide, but on heating, it is driven off again, thus causing the precipitation to take place more rapidly, and to a much greater extent, than without its use.

The washing process follows the ripening and then the emulsion is poured onto plates and dried, and we have at last our commercial dry plate.[3]

Before leaving this part of the subject we should say that when certain coloring matters are added to the sensitive emulsion they render it more sensitive to the kinds of light which they absorb. Utilizing this fact, we are able to obtain by treating the emulsion, either before or after spreading it on the plate, with certain dyes, what is known as the orthochromatic and panchromatic plates. We have already had occasion to mention these. It should be said here, that Bancroft, in a paper before the Eighth International Congress of Applied Chemistry, states the following, which is of interest in this connection:

"In 1818, Grotthus formulated two laws of photochemistry:

I. Only those rays of light which are absorbed produce chemical action.

II. The action of a ray of light is analogous to that of a Voltaic cell.

The first is attributed to Draper and is universally accepted."

Bancroft proposes, however, the following generalization in the place of these:

"All radiations which are absorbed by a substance tend to eliminate, or decompose, that substance. It is entirely a question of chemistry whether any reaction takes place, or what the reaction products are." In other words, sometimes the system is too stable for the light to bring about a change, or it may require a reducing agent to be present before a decomposition will take place.

No matter how carefully the emulsions are prepared, it cannot be predicted beforehand just what the exact sensitiveness (that is, speed with which they will be acted on by light) of each batch of the emulsion will be. The reason for this is, most probably, that the bromide particles are not all of uniform size, but vary in size—in high speed emulsions, according to Mees, from 1 μ to 3 μ in diameter.

Mees shows that "since the mass of silver which is deposited on development is equal to the number of grains times the cube of their diameter, and all grains, of whatever diameter, require the same amount of energy to make them developable, then for exposures of different sized grains the density produced for a given exposure will vary as the cube of the diameter of the grain." It follows that sensitiveness varies in the same proportion.

But it was just said that the grains vary from 1 to 3 μ in diameter, "so that, without any difference in sensitiveness of single grains, these mere variations of size would give a range of sensitiveness from 1 to 27, supposing that these emulsions could be made homogeneous. But they are not homogeneous. On the contrary, they contain grains of all sizes, therefore, the sensitiveness will depend upon the distribution of the different sized grains, and so also will the shape of the plate curve, which represents the relation between the density and logarithmic exposure."

In the low-speed emulsions no such relation between sensitiveness and exposure can exist, according to Mees, because, he believes, the structure of the emulsion is entirely different; it is not composed of comparatively large single grains, each grain surrounded by gelatin, but is made up of "small complex mixtures of grains which would require more than one unit of energy for each separate unit of the complex." In the latter case, therefore, complexity as well as size of grain affects the sensitiveness.

It might be said further in this connection that Mees seems to favor Quincke's view of the structure of the emulsion—which is not an emulsion at all in the true sense of the word, that is, a colloidal emulsion, a colloid being defined, according to Wo. Ostwald, as a substance in a state of subdivision, the individual particles of which have diameters not exceeding about 100 $\mu\mu$, and not smaller than about 1 $\mu\mu$ (1 $\mu\mu = 10^{-6}$ millimeter).

Quincke suggests that the gelatin structure is similar to that of a sponge, and the gelatin emulsion may be considered "to consist of crystalline granules of silver bromide inhibiting cells of a jelly, which, on setting, surrounds each grain (or complex of grains) of the silver salt with a wall of gelatin. Through the channels in the gelatin ions and molecules of the substances dissolved in the developer can travel with ease at a velocity comparable with their rate of diffusion in water, while penetration through the cell walls is a much slower and more difficult process."

A discussion of the sensitive film and the evolution of the modern dry plate would not be complete without mention also of kodak and moving picture films, which have such an extensive use to-day.

The film consists of a celluloid base, corresponding to the glass plate. On one side of this is spread the sensitive emulsion, similar to that used on the orthochromatic plates. On the other side of the celluloid base is spread a film of plain gelatin. The object of this is to prevent curling, due to the contraction of the gelatin on drying. If the gelatin is on both sides of the celluloid, the contraction on one side is counterbalanced by that on the other. The moving-picture film does not have this back coating of gelatin. Some moving-picture films have a base containing cellulose acetate instead of cellulose nitrate, which, with camphor, forms the ordinary celluloid. The latter is inflammable, while the celluloid containing the acetate is not.

Patents in the German Dye Industry

PATENTS have been multitudinous in connection with the evolution of the German coal-tar dyestuff industry. From 1876 to 1912 they numbered 8,062, or 224 annually on an average. Many corresponding patents were taken out in other lands, especially in France and Great Britain. The number in the United States was 2,432.

But very few of the important intermediates have been patented. Not a few dyestuffs have been patented by non-German inventors. Most patents cover a vast range of possibilities, and protect the manufacture of thousands of theoretical dyestuffs, of which an infinitesimal number ever win a place in the world's markets. In the case of the 921 dyes in current use at the beginning of 1913, 762 German patents were involved. Of these, 485 were originally patented in the United States. One-half of the American patents have expired. Many of the remaining patents expire this year or in the immediate future. Over 50 per cent of the current dyestuffs were never patented in the United States.

The general situation shows clearly that, as far as patent protection is concerned, numerous dyes have been patented by non-German inventors, that many dyestuffs have never been patented, that the patents on many others have expired, a considerable number each year, since 1880. In spite of all this apparent freedom, and the absence of all patent protection on the production of the intermediates requisite for dyestuff manufacture, efforts in other countries to challenge and contest Germany's dominant position in the dyestuff industry have been few, and practically futile.

As a matter of fact, Germany has demonstrated her ability to outrank the entire world in making patentable compounds from nonpatented intermediates and, in addition, to manufacture these intermediates in open competition with all rivals.

In its ultimate analysis, the situation shows that German chemists and captains of industry have actually done the bulk of the hard and complicated labor inherent in the creation and organization of a vast branch of manufacture, and that they have not hesitated to use the power associated with its hardly won national predominance to prevent effectively any serious competition in industrial lands.—*Report of Bureau of Foreign and Domestic Commerce, U. S. Department of Commerce.*

[2] These procedures should by no means be considered as exact directions for making plates. They merely give the principles of the process. For the earlier methods see Abney's Photography with Emulsions, 1885; Eder's Ausführliches Handbuch der Photographie, th. iii, "Die Photographie mit Bromsilber-Gelatine und Chlorsilber-Gelatine," Halle, 1886.

[3] R. J. Wallace has pointed out that accompanying the change in size there is also a change of structure, i. e., a change of allotropic modification of the bromide. It is quite possible for one allotrope to be more sensitive to light than another.

[3] I have not attempted to give in detail every step in the process, and some less important steps have been entirely omitted. Besides, many of these steps are known only to the plate maker.

NEW BOOKS, ETC.

A NEW FORD ENGINE CHART. By Victor W. Pagé. New York: The Norman W. Henley Publishing Company. 25x38 inches, on heavy bond paper. Price, 25 cents.

This chart gives detailed sectional and complete views of the Ford Power Plant, indicating every essential feature; and has comprehensive and systematic tables that enable every description of motor trouble to be quickly diagnosed, and the correct remedies applied. It is just the thing for the car owner to tack up in his garage, and also carry in his pocket for quick and ready reference. It was prepared by an expert mechanical engineer from his own personal experience with the car, and is most complete and reliable.

THE OFFICIAL AMERICAN TEXTILE DIRECTORY. Containing Reports of All the Textile Manufacturing Establishments in the United States and Canada, etc. Compiled by the Textile World Record. Boston: Lord & Nagle Company, 1915. 8vo.; 639 pp. Price, office edition, $3; travelers' edition, $2.

The 1915 issue of this Textile Directory maintains its reputation for exhaustiveness and accuracy. Under each town are listed all the textile mills of the place, and a key letter to the right of the firm name indicates the nature of its activity—whether in cotton, woolen, print, silk, or knitted goods; or it may be a bleachery, a dyeing establishment, a flax mill, or a finishing works. The towns are in turn grouped under their respective States, and there is a map of each State showing all the mill towns, giving their population, and indicating the railroad stations and railroad connections. The information concerning each mill includes names of officers, capacity in machinery, kind of power, and names of buyers and sales agents. The Directory is compiled only after personal canvass and official reports from the trade, and the publishers' faith in its reliability is evidenced by their offer of reward to those who bring errors or omissions to their notice. Five indexes make all the information of the Directory easy of access.

THE NEW YORK CHARITIES DIRECTORY. Being an Encyclopædia of Social Service in or Available for Greater New York. By Lina D. Miller. New York: Charity Organization Society, 1915. 8vo.; 800 pp. Price, $1.

This year's issue of the Directory is marked by a simplified arrangement of material. The change greatly facilitates reference and will commend itself to the busy inquirer. The word "charities" is used in its broadest sense, social, civic, religious and educational agencies all being included in the lists. The Topical Index alphabetically places the specific line of activity, such as child welfare, milk stations, or vocational schools. The Name Index identifies some 6,000 individuals prominently connected with the listed agencies. A Church List gives 1,800 churches of all denominations in Greater New York. The greatest pains have been taken to mention only reputable organizations, and to make all the information given as accurate and up-to-date as possible.

CONSERVATION OF WATER BY STORAGE. By George Fillmore Swain, LL.D., Gordon McKay, Professor of Civil Engineering in Harvard University. New Haven: Yale University Press, 1915. 8vo.; 384 pp.; illustrated. Price, $3 net.

In these addresses a highly important subject is handled with rare judgment and skill. We have outlined the general problem of conservation as it confronts the people of the United States, and the relation of the conservation of water to the conservation of other resources is explained. The water-power problem includes questions of federal control, and in discussing this aspect Prof. Swain emphasizes the legal technicalities which it is so necessary to understand before an intelligent grasp of the situation may be attained. He brings this portion of his subject to a close in a masterly summary of his own conclusions relative to the development of water-power on navigable streams and on the public lands. The technical side of water-power development is then taken up, and water storage, both in open reservoirs and within the ground, is discussed at length. The subject of floods and their prevention brings this noteworthy contribution to the literature of water-power to a close. Much of its value lies in the author's ability to take due cognizance of diverse and often antagonistic elements, and to suggest means and compromises that will largely safeguard all interests while furthering a plan of action that shall encourage the utmost possible development of resources.

LIQUID DROPS AND GLOBULES. Their Formation and Movements. By Charles R. Darling, Associate of the Royal College of Science, Ireland. New York: Spon & Chamberlain, 1914. 12mo.; 83 pp.; 43 illustrations. Price, 75 cents.

Prof. Darling's little volume is based upon three lectures before popular audiences, and describes experiments that, while exhibiting to the full the mysterious behavior of the liquid drop under varying conditions, may be repeated without the aid of any special knowledge or manipulative skill, and at small expense. The elastic surface skin of liquids is demonstrated, true liquid spheres are produced, liquid columns are formed, and patterns are made by drops floating on hot surfaces. The phenomenon of the "devouring" globule is another of the many interesting experiments presented by the author.

THE LOG OF A TIMBER CRUISER. By William Pinkney Lawson. New York: Duffield & Co., 1915. 8vo.; 214 pp.; 32 illustrations. Price, $1.50 net.

It may not be unnecessary to state for the benefit of the uninitiated that a timber cruiser is not a vessel engaged in carrying lumber, but a man whose duty it is to tramp untraversed wilds and make timber estimates. The volume conveys in a readable form much needed information concerning the Forest Service and its work, and touches upon the daily life and duties of supervisors, assistants, rangers and guards. The manipulation of the plane table, alidade and stadia rod in the practically unsurveyed Black Range country, at altitudes varying from 6,000 to 10,000 feet, is trying enough at best; when the reconnaissance party is called upon for such extra duties as combating forest fires, to say nothing of the nocturnal incursions of skunks, bob-cats, snakes and tarantulas, it may easily be realized that the activities of the timber cruiser are not exactly in the nature of a picnic. Existence is largely maintained upon slumgullion, which the author defines as a kind of soupy stew, or stewy soup, the ingredients of which evade analysis. It is a most genuine and spontaneous narrative he gives us of this arduous life, its everyday routine and achievements, its humorous offerings in character and in situation, and its lessons in human probity, resourcefulness and determination.

MODEL POWER BOATS. A Complete Manual on the Designing, Building, and Running of all kinds of Model Self-propelled Boats, Steam, Gasoline and Electric. By E. W. Hobbs, Associate of the Institution of Naval Architects. New York: Spon & Chamberlain. 8vo.; 338 pp.; illustrated. Price, $2.

The recreation afforded by the designing, building and racing of model power boats has much to commend it besides its fascination. It involves scientific and technical considerations, leads to the solution of practical problems, and is excellent preparation for a maturer study of naval architecture. The author cites the elements necessary to the practical model, and sets forth the theories of floating bodies and the complexes which act upon them. Such mechanical details as boilers, burners, and gasoline and electric motors follow, and a chapter is given over to the deck fittings and the superstructures. There are numerous designs and working drawings. In England model yacht racing has been placed upon an organized basis, and London alone has a half-dozen clubs devoted to the sport. The parent body, the Model Yacht Racing Association, promotes indoor meetings, arranges exhibitions and regattas, and generally furthers design. Their rules are included in this volume, and there is a glossary of the technical terms employed.

WRITTEN ENGLISH. A Course of Lessons in the Main Things to Know in Order to Write English Correctly. By Edwin C. Woolley, Ph.D. New York: D. C. Heath & Co., 1915. 12mo.; 300 pp. Price, $1.

The author's contention that our present methods of instruction in composition are failures is certainly borne out by the facts. He designates these methods as desultory, irregular, and insufficient, and his work seeks to establish instruction upon an adequate and effective system of discipline. Literary excellence is not aimed at, but grammatical, rhetorical and mechanical correctness are in the main well pursued. There are some rather regrettable omissions. For example, even the educated American has but an imperfect knowledge of the proper use of "shall" and "will."

This important point seems to have been entirely overlooked by the author; yet nothing so reveals the lack of thorough grounding in the use of the English language as the misues of these two little words in making a simple statement or in expressing determination.

THE AMERICAN FERTILIZER HAND BOOK. The Standard Reference Book and Directory of the Commercial Fertilizer Industry and Allied Trades. Philadelphia: Ware Brothers Company, 1915. 4to.; illustrated. Price, $1.

A number of instructive articles, statistics and tables precede the directories of this year book. Of the directories, the first lists the fertilizer manufacturers of the United States, arranged by States, and is keyed to indicate the exact nature of their business; the second is a classified enumeration of the allied trades—manufacturers of fertilizer machinery and factory equipment, manufacturers of and dealers in materials and supplies, brokers, importers and exporters, chemists, phosphate miners, sulphuric acid plants, and lead burners. The third list is of cottonseed oil mills, arranged by States; and the fourth gives the packers and renderers, keyed to discriminate between meat packing houses, rendering plants, and manufacturers of fertilizer material. The above summary will demonstrate the wide scope of the hand book, and its indisputable value to buyers and others.

THE TREASURE OF HIDDEN VALLEY. By Willis George Emerson. Chicago: Forbes & Co., 1915. 8vo.; 431 pp. Price, $1.25.

Of literary style Mr. Emerson's latest novel has nothing to boast. The conversation is irritatingly stilted. To say that two young Westerners "proceeded to dispose of the comestibles," when all they did was to enjoy a picnic lunch, is unjust to their bubbling youth; and the author speaks of mixed metaphors when his reference is really to a couple of adjectives and a simile. Yet, with all these faults, and with three love episodes running smoothly to a tame conclusion, Mr. Emerson manages to give us a breezy and red-blooded yarn that triumphs over its handicaps and pleasantly passes away an idle hour.

THE BRITISH NAVY. Its Making and Its Meaning. By Ernest Protheroe. New York: E. P. Dutton & Co. 8vo.; 694 pp.; 289 illustrations in text, 8 plates in color. Price, $2.50 net.

Mr. Protheroe's recital, which makes stirring reading both for youth and age, opens with ancient navies and their achievements, and closes with the naval side of the European conflict up to November last. The historic struggles by which England acquired and maintained the mastery of the seas are described at some length. There is much concerning the advent of steam and the evolution of the ironclad, and complete tables of the British naval strength of to-day are given. These show date of completion, dimensions, tonnage, horse-power, speed, coal capacity, complement, armor and armament. The text illustrations are not particularly good, but in the colored plates we encounter some striking effects. The work is addressed to the youth of the British Empire, but its inspirational appeal, its orderly historical reviews, and the timely and vital information it offers, merit the favor of a much wider circle of readers.

FLAGS OF THE WORLD. Past and Present. Their Story and Associations. By W. J. Gordon. New York: Frederick Warne & Co., 1915. 8vo.; 256 pp.; 500 illustrations in color and black and white. Price, $2.25 net.

He who looks on a flag looks on history. Its symbolism tells of the rise and fall of dynasties or, as in the case of our own flag, the birth, progress and achievements of a nation. It may be that here, for the first time, many boys will trace our star-spangled banner back to its origin in the emblem of the East India Company. Mr. Gordon unfurls for us the flags of the world, and opens to us their hidden meanings. The illustrator, W. J. Stokoe, has seen to it that both in coloring and proportion the pictured flags are absolutely correct. The long chapter on signaling clears away the general misunderstanding of this subject and substitutes a clear knowledge of basic principles.

THE SOLAR SYSTEM. An Astronomical Unit. A Work of Deduction Based on a Fundamental Hypothesis. By George Adam, M. D. San Francisco: John J. Newbegin. 8vo.; 211 pp.; illustrated.

Dr. Adam's works always evidence deep thought, and present hypotheses worth pondering. In the volume in hand the electrical theory of creation is amplified in an interesting manner. The hypothesis which he considers fundamental to the laws of force may be briefly conveyed by the following tenets: That the ether is the simplest form of matter, molecular in construction; and that electricity, in the broadest sense of the term, is its chemistry. He regards these tenets as the key to a comprehensive generalization, and holds that such a generalization must of necessity proceed from intuitional thought or imaginative effort. To his credit it must be observed that this is with him but the starting point, and his theories are built up with closer reference to established facts and conditions than is often the case in intuitional or conjectural works. We are promised a more detailed and comprehensive volume later, covering the same ground.

ELEMENTARY ELECTRICITY. And Electric Systems on Motor Cars. By Harvey E. Phillips and James M. Copland. Dayton, Ohio: Auto Electric Systems Publishing Company. Pamphlet; 80 pp.; illustrated. Price, 40 cents.

This pamphlet explains to the inexperienced man the principles and laws of electricity, the meaning of the terms in common use, and the operation of elec ric systems as applied to motor cars. In the instructions, the question and answer method is employed to some extent, with memoranda pages for the convenience of the student.

OUR PALACE WONDERFUL. Or Man's Place in Visible Creation. By the Rev. Frederick A. Houck. Chicago: D. B. Hansen & Sons; 1915. 12mo.; 173 pp.; illustrated. Price, $1.25.

The ultimate purpose of this attractive little volume is to induce, or at least to confirm, an attitude of belief in scriptural revelation. To this extent the work must be classed as religious. It pursues the well-known "argument from design," but in this pursuit it embodies a charmingly clear condensation of scientific and natural knowledge. For the sake of brevity the animal kingdom, exclusive of man, is but casually dealt with. The author's attention has been concentrated upon the mineral and vegetable kingdoms, and upon man himself.

THEATERS. Their Safety from Fire and Panic. Their Comfort and Healthfulness. By Dr. William Paul Gerhard, C. E. New York: The Baker & Taylor Company, 1915. 8vo.; 110 pp. Price, $1 net.

"Theaters" puts into permanent form articles contributed by the author to publications of the British Fire Prevention Committee and to *Appleton's Popular Science Monthly*. Of late much attention has been bestowed upon the feature of safety in the theater, but comfort and healthfulness are still sadly neglected. The first division of the volume deals with fire and panic precautions, the exit facilities, fire prevention, and measures for dealing with an incipient blaze, with means for guarding against panic. The second division covers ventilation, heating, lighting, furnishings, plumbing and water supply, and general sanitary inspection. The work is timely, and its recommendations are sensible and practical.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, AUGUST 21, 1915

Charles Allen Munn, President
Frederick Converse Beach, Secretary
Orson D. Munn, Treasurer

All at 233 Broadway, New York

Entered at the Post Office of New York, N. Y
As Second Class Matter

Copyright 1915 by Munn & Company, Inc.

The Scientific American Publications

Scientific American Supplement (established 1870) per year . . . $5.00
Scientific American (est. 1845) " 3.00
American Homes and Gardens " 3.00

The combined subscription rates and rates to foreign countries including Canada, will be furnished upon application.

Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 233 Broadway, N. Y.

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

Back Numbers of the Scientific American Supplement

SUPPLEMENTS bearing a date earlier than January 3rd, 1914, can be supplied by the H. W. Wilson Company, 39 Mamaroneck Avenue, White Plains, N. Y. Please order such back numbers from the Wilson Company. SUPPLEMENTS for January 3rd, 1914, and subsequent issues can be supplied at 10 cents each by Munn & Co., Inc., 233 Broadway, New York.

WE wish to call attention to the fact that we are in a position to render competent services in every branch of patent or trade-mark work. Our staff is composed of mechanical, electrical and chemical experts, thoroughly trained to prepare and prosecute all patent applications, irrespective of the complex nature of the subject matter involved, or of the specialized, technical, or scientific knowledge required therefor.

We also have associates throughout the world, who assist in the prosecution of patent and trade-mark applications filed in all countries foreign to the United States.

MUNN & CO.,
Patent Solicitors,
233 Broadway,
New York, N. Y.

Branch Office:
625 F Street, N. W.,
Washington, D. C.

Table of Contents

	PAGE
The Conductivity of Metals.—By Sir J. J. Thomson.—4 illustrations	114
Extinguishing Fire With Kerosene	114
Pontoon Bridges and Rafts.—6 illustrations	116
The Lignite of North Dakota	116
The United States battleships in the Panama Canal.—3 illustrations	117
Cooling Water and Air for Power Plants.—2 illustrations	117
Measurements With the Micropyrometer	117
An Excursus on Geological Time	118
Rank of Coal Producing States	119
Electrolytically Produced Hypochlorites	119
The Government Uses Motion Pictures.—By C. J. Blanchard.—13 illustrations	120
The Therapeutic Uses of Preparations of the Ductless Glands.—I.—By Robert G. Torrey	123
Hospital Efficiency	123
Foreign Sources of Artificial Dyestuffs	123
Hydraulic Turbines.—By H. J. Kennedy.—5 illustrations	124
Evolutions of the Modern Dry Plate.—By E. P. Wrightman	126
Patents in the German Dyestuff Industry	127
Book Notes	128